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BLOOD PRESSURE

CAUSE, EFFECT, AND REMEDY

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BY

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AND

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PREFACE

This volume goes thoroughly, but without technicalities, into a subject that is of growing concern to both doctor and patient. The doctor is concerned because he sees more and more clearly the relation of abnormal blood pressure to heredity; to acute infectious diseases; to arteriosclerosis; to diseases of the kidney; and finally to old age and the maladies, so often fatal, incident to it. The non-medical man is concerned because he is learning that the development of high blood pressure is a process rather than a disease; that symptoms develop rather late in its course; and that preventive measures must, therefore, be taken early.

Blood Pressure gives the non-medical man in plain, readable English, the information he would like to have.

LEWELLYS F. BARKER, M.D.
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BLOOD PRESSURE
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CHAPTER I

MISCONCEPTIONS WITH REGARD TO BLOOD PRESSURE

THE subject of blood pressure is enjoying to-day what amounts almost to a vogue. It has come prominently before the medical profession of late and has had to yield up some of its secrets under the searching light of investigation. World-wide reports of these researches are crowding the medical literature; physicians everywhere, possessed of this newer knowledge, are paying increased attention to blood pressure and to the disorders connected, in one way or another, with it. As a result, one finds what one might expect to find, namely, that the patient is impressed by the stressing of this subject, new to him, especially when he finds that blood-pressure troubles are peculiarly incident

to the senescent years. He looks then at others of his own age about him and discovers, in conversation, that they, too, have been warned about their blood pressure. He even finds articles about blood pressure in the popular magazines. It finally becomes more or less common knowledge to him that the matter of blood pressure is somehow mixed up with many of the serious and fatal diseases of middle and later life, and he becomes disturbed about his condition and perhaps downright fearful because of this new medical bugbear.

Now fear is an inefficient sort of emotion, seldom bringing any advantage to its owner. The surest way to destroy it is to drag it out into the light of day and make it stand and deliver. Frequently it shrivels and reveals its meannesses, and disappears forever as a fear. There is always a real satisfaction in overcoming a fear. Conquer it and you secure a new peace of mind and perhaps also a hint as how best to avoid the attacks of other similar pestiferous causes of anxiety.

The situation to-day with regard to blood pressure is a case in point. Before the non-medical man has heard the subject mentioned many times

he has learned to associate it with such dreaded things as Bright's disease, apoplexy, and serious heart disturbances. He knows, too, that these maladies increase in frequency in the second half of life and he becomes more and more anxious to know something about this "terrible" blood pressure and particularly how he may escape its dangers. The medical fraternity is just as anxious to tell what it knows about the subject, admitting all the time that its knowledge is yet imperfect, in order that these insidious foes of later life may be caught in the beginning of their work and rendered innocuous. Such a course is but in line with the whole trend of preventive medicine to-day. Prevention is coming to be of far more importance than cure. Indeed, it is easier; and economically, at least, it is of prime importance in the whole field of medicine, for sickness is far more costly to the nation in the loss of work and wages than all the perils of field and flood added together. One need only think of the conquest of smallpox, of yellow fever, of typhoid, and of malaria, to be convinced of the financial value of preventive medicine.

But though the gospel of prevention of disease

has become an integral part of the physician's creed, it creeps but slowly into the code of the non-medical man. He is all too accustomed, especially in America, to disregard his physical being until symptoms that will not be denied make it plain to him that something is the matter with him. This is the sad story of cancer and of tuberculosis. It is the layman's right, therefore, to have at his disposal such information as will help him to avoid the beginnings of disease; and, equally, it is his duty to inform himself of preventive measures, to the end that he may live out his threescore years and ten in comfort. Not less is the obligation of the physician to put his knowledge before the public in a simple and understandable form. Only thus does he perform his whole duty as a physician.

It is always wise, before building, to clear the ground of obstructions, and there are two main misconceptions with regard to blood pressure that must be disposed of.

The first misconception is that the subject of blood pressure is new, or that there is something new about it that constitutes a hitherto unknown menace to the health of the nation. Nothing could

be farther from the truth. Appendicitis was not a new disease in the last two decades of the nineteenth century, though only then was it recognized. From time immemorial it has been known that blood vessels bleed when cut; the dullest can argue the cause as some sort of pressure within the blood vessels. When Harvey discovered the circulation of the blood and published his work, *De Motu Cordis,* in 1628, he recognized the fact that the heart propelled the blood by exerting intermittent pressure upon it. Medical investigation moved slowly in those days, and it was not until more than a century later, in 1733, that Stephen Hales, a clergyman, demonstrated and measured accurately the blood pressure in the arteries of a horse. Random observations were made from time to time, but it was only in the last quarter of the past century, that golden era of medicine, that observations of blood pressure could be made without opening the arteries and so became applicable to man. Indeed, routine estimations of blood pressure have become possible only in the last few years, with the development of the handy little arm-band, pump, and pressure gauge combination now so familiar;

so that, in a sense, our clinical knowledge of blood pressure is new. This is quite different from saying that disorders of the pressure are new. They are not. It is only the understanding of them that is new—an understanding brought about through an inconceivable number of observations and experiments by all manner of medical men in all parts of the globe. One might as well say that the revolution of the earth is new because it has been discovered within the memory of man. No one would be so silly as to believe such an assertion; and no one need fear any new threat against life from his circulatory system. Rather should we all rejoice that an old danger has been recognized and branded for what it is and that we are slowly but surely getting at the causes of it; and so making our way toward its prevention.

The other misconception that blood pressure, in and of itself, is something wrong is easily disposed of. No fluid moves onward unless there be pressure of some kind upon it. The brook flows down its bed because of hydrostatic pressure dependent upon gravity. The geyser spouts, water moves through its pipes, blood through its vessels only in obedi-

ence to some compulsion. Without pressure of some kind or degree there could be no circulation, and hence, in the case of the body, no life. There is nothing that should alarm in the mere fact of blood pressure; it is a physiological necessity. But the blood pressure must remain within certain limits if health is to be conserved. In the plumbing of a house the pressure must be great enough to overcome gravity and the friction of the moving water against the inside of the pipes; and yet not so great as to burst the pipes. The limit of variation is evidently wide. So, in the body, the blood pressure may vary a good deal, and does vary, under many different conditions, without becoming abnormal. It is only when it is raised or lowered beyond the limits of its normal swing, and particularly when it is maintained permanently or for some time at that abnormal figure, that any concern need be felt.

Further, the pressure varies not only from time to time, but also from one part of the circulatory system to another. It is highest in and near the heart; lower as the smaller arteries are reached; and lowest in the veins. These phenomena are, of

course, true of any circulation. But now comes a marvel: delicate apparatus exist within the body by which the blood pressure may be so varied locally as to afford more or less blood to individual organs. Were it not for these normal local shifts in pressure always going on in the body with changing activities and moods it would indeed go hard with the organism and its balance. Now the stomach demands more blood for the purpose of carrying out its work of digestion; now the brain, in thinking; now the muscles, in their activities. All over the body are organs which, called upon to increase their activities, ask for more nutrition and more oxygen and require a greater flushing away of waste products. Just as more freight cars must be sent to the points of greatest commercial activity, so must more blood be provided for active organs; just as centers of trade change from one part of the country to another, so do the centers of greatest organic demand in the body change. And in order that the body may be ready to send extra blood to any given organ at a moment's warning, the whole blood content of the body is held

always under a certain amount of pressure. This is sensible; for it is much easier to open the floodgates of a certain organ to an already existing pressure than it would be to create an increase of pressure instantly at that one point. The mechanism of these local adaptations of pressure and flow are matters for a later chapter; mention of them here is merely to emphasize the fact that blood pressure is normally subject to variations.

With the foregoing paragraphs in mind we must acknowledge at once that blood pressure is in itself a normal phenomenon; that it is necessary to the maintenance of circulation and of life; that in degree it varies from one part of the body to another with changing bodily needs; that even at any one point in the body it varies from hour to hour and even from minute to minute. We must remember, however, that these fluctuations, though sometimes surprisingly large, lie within certain fairly well-defined limits in the healthy person; and that it is only when the pressure figure transgresses those limits that it becomes harmful. The understanding of what those limits are and when they

are transgressed and what the significance of the transgression is leads far into realms not yet well charted. Certain principles, however, stand out and may be stated. They involve an understanding of the normal mechanism of the circulatory system.

CHAPTER II

HEART AND BLOOD VESSELS

In the preceding chapter, an analogy was drawn between the circulation of the blood in the body and the circulation of water in the pipes of a city water-supply system. The analogy holds good, however, only up to a certain point; beyond that the divergence of the two systems becomes so great that comparisons fail. The chief difference is that one system is inanimate, with rigid tubes and predetermined flow and pressure; whereas the other is animate, with living tubes capable of expansion and contraction, with a pulse which becomes automatically adjusted in its rate and volume to the immediate necessity, and with such a marvelously accurate and rapid reciprocal adjustment between heart and vessels that, in the absence of unusual outside influences, the circulation is ever maintained at its maximum efficiency. Since the blood pressure is primarily dependent upon the functions

of the heart and blood vessels, some understanding of the architecture of the circulatory system and of the methods by which it works is necessary before we attempt further to discuss the blood pressure itself.

The primary motor of the circulation is, of course, the heart. Though a comparatively simple one, it is a highly efficient pump, built almost entirely of muscle. It contains several chambers through which the blood stream is directed always onward because of the interposition of valves that prevent a backward flow. The onward motion of the blood is intermittent and is produced by the periodic contraction of the walls of the heart-chambers themselves; when the walls contract, the size of the chamber is diminished; hence the contained blood is pressed out of it. A complete vertical partition divides the heart into right and left halves, much after the fashion of a pair of modern duplex apartments. Each half contains an upper chamber (auricle) and a lower chamber (ventricle); the auricle receives the blood from the veins and passes it on to the ventricle; and the ventricle then propels the blood into the arteries. The heart is,

thus, essentially a pair of similar pumps lying side by side, each with two chambers, one above the other. For a moment it will be convenient to disregard the right side or half of the heart and to consider the left side or half only. The left auricle, then, receives the blood from the veins of the lungs, passes it downward through a valve to the left ventricle, which, contracting in its turn, forces the blood out through another valve into a large arterial vessel called the aorta. The aorta gives off branches almost immediately known as the arteries to the head and to the arms; it then continues downwards along the spinal column, giving off other branches to the internal organs as it goes, itself becoming gradually much reduced in size until it splits at last into the two great arteries that supply the legs with blood. Each of these arterial offshoots branches, exactly as does a limb of a tree, into an ever-increasing number of smaller and smaller vessels with thinner and thinner walls until every part of the body is supplied with a multitude of tiny vessels, called the arterioles. Thus far in its course from the lungs the blood has been merely in transit; now it must yield its oxygen and its

nutrition to the tissues and receive waste products from them; consequently an even simpler form of blood vessel becomes necessary in order to facilitate the exchange of liquids and gases. The arterioles, already enmeshed in the depths of the various organs, accordingly divide still further into tiny vessels with walls so thin that they are hardly visible even under the microscope; and with caliber so small that the tiny cells of the blood must pass through in single file. Years ago the name "capillaries" was given to these tiniest, shortest vessels by the older anatomists, who saw in them a resemblance to short sections of a hair! Here in the inmost recesses of every organ occurs the vital interchange of the life-giving substances (including food and oxygen), carried in the blood and the waste products (including carbon dioxide) of which the tissues must quickly rid themselves. The barter takes place in an amazingly short interval of time and space. The blood, thus impoverished of food and oxygen and loaded with waste products, must now be hurried on again for purification and replenishment. Each capillary merges in a tiny vessel with somewhat thicker walls, known as a small vein

or venule. This joins its neighbor to make a larger vein, and as this union of one pair meets and unites with that of another, the resulting vessels become larger and larger, much as streams increase by confluence on their way to the sea; the union of ever larger veins continues until at last two great veins (the superior and inferior vena cava) are formed (one from the head and arms, the other from the lower half of the body), which together pour the entire blood stream into the auricle of the right side of the heart. Thence, just as on the other side of the heart, the blood passes through a valve into the ventricle and is pumped into and through the arteries and capillaries of the lungs, where it gives off carbon dioxide and receives new stores of oxygen. Returning through veins from the lungs, it is led directly to the auricle of the left side of the heart and the circle is thus completed. The part of the system from the left ventricle through arteries, capillaries and veins to the right auricle is known as the "greater or general circulation," whereas the part of the system from the right ventricle through the lungs to the left auricle is known as the "lesser or pulmonary circulation."

It has been said above that a blood vessel is a living thing, capable of contraction and of expansion; that is, its caliber, or lumen, can be decreased or increased. These changes in caliber occur principally in the arteries and only to a much less extent in the capillaries and veins. The contraction is accomplished by the tensing, under nerve control, of tiny little muscle fibers which run in a circular fashion within the walls of the arteries. Through nerve control the tiny muscles can be made to relax and to allow the vessels to dilate on the one hand, and on the other hand they can be made to contract also through nerve control so that less blood can pass through. The presence of this muscular layer accounts for the thickness of the arterial walls as compared with those of the veins, in which the musculature is so delicate as to be almost lacking. The largest relative amount of muscle tissue is found in the smaller arteries and arterioles, a fact which is of prime importance in the maintenance of blood pressure, as later will be seen. Yet even these sturdy little muscles would not be able to withstand the very large expansile force exerted in the larger vessels, already full of blood, as the

heart suddenly throws into them, again and again, a large additional volume of blood, were it not for the presence in the wall of the vessel of many elastic fibers. These allow the walls of the vessel to give at the moment of passage of the pulse wave and enable it to return to its normal size as soon as the wave has passed.[1] Finally, a layer of (dense) fibrous tissue surrounds the vessel and lends strength to the whole structure.

The necessity for such a combination of strength and elasticity in the arteries is easily realized when it is considered how great a volume of blood they receive from the heart at each beat. If the forward motion of the blood is to be passed on to the smaller arteries with their thinner walls their larger brothers must absorb, by means of elasticity, at least some of the expansile force of the pulse wave. To drop for a moment into technical terms, the kinetic energy of the heart must be transformed, temporarily, to some extent into potential energy. The

[1] Very likely the muscular layer contracts again immediately behind the pulse wave and so helps the heart to move the blood stream onward. In some of the cold-blooded animals, for instance, certain of the vessels show definite rhythmical contractions and thus take some of the burden of propulsion off the heart.

result is ideal. The intermittent advance of the blood in the large arteries is changed gradually into a steady onward flow as the smallest arteries (or arterioles) and capillaries are reached. The process is aided by the ever-increasing total cross area of the bed of the blood stream toward the periphery due to the continuous branching of the vessels. It is estimated that the total cross area of the arterioles is something like eight hundred times that of the cross area of the aorta near the heart. The broader the stream the slower and the smoother the flow. By the time the blood reaches the capillaries, therefore, its progress is leisurely and the pulse wave has been lost—flattened out, as it were, by the smaller arteries and arterioles. On the far side of the capillary system there is nothing to reconstitute the pulse wave, and the blood returns to the heart through the veins with a steady motion, accelerated somewhat by contraction of the muscles in the walls of the veins and more by the creation of a vacuum within the chest during breathing.

The tiny muscles in the walls of the blood vessels, like muscles elsewhere in the body, contract only when an impulse reaches them through a nerve.

Now there is one system of nerves which derives its impulses from the thinking part of the brain; messages pass along them only at the command of the "will" and are carried to muscles which are under voluntary control, such as those which move head, trunk, limbs, eyes, tongue, etc. This system of nerves is called the "cerebrospinal." The other system of nerves, different and separate from the first in many respects, yet intimately connected with it by many cross-overs, supplies those muscles which are not under the control of the will. These nerves form the vegetative nervous system; they run to the musculature of the internal organs, such as the stomach, intestines, bladder, heart, diaphragm, glands, blood vessels, etc. It is plain that these organs are not under the direction of the "will." It is plain, for instance, that one cannot voluntarily initiate, govern, or stop the contractions of the stomach and intestines that occur during digestion by thinking about them. Thinking about digestion may influence it indirectly through the emotions and the sympathetic nervous system but not directly through the cerebrospinal nervous system. It is impossible voluntarily to stop breathing for longer

than a certain time, or voluntarily to make the heart beat faster or slower. Sweating, the production of saliva, the manufacture of urine, or of bile or of pancreatic juice, to name only a few of the very large number of complex vital processes, are fortunately carried on automatically, not voluntarily. If it were not so, if the body were so constituted that conscious thought had to be given to the direction of all these activities, man would have no time for anything except to keep his bodily machinery properly at work. He could never even dare take time to sleep, for the beating of his heart and his breathing would stop at once. Even if it were possible for man to master all the intricacies of the vital functions, if these were to be left to him to control voluntarily, he would soon die from sheer exhaustion and the race would come to an end abruptly.

The vegetative nervous system is not only the mechanism for the perpetuation of the automatic functions but it also can hasten or retard these functions; it plays one function against another so as to favor the maintenance of that harmony and equilibrium throughout the body that is neces-

sary for health. The delicate, exact, and instant coördination of the various automatic functions, for the benefit of the body as a whole, is so smoothly accomplished that no one is conscious of it and few even think of it; yet the wonder is as solemnly impressive as the ordered movements of the stars or as the growth of the white lily from the black muck. Thought of it can lead only to reverent awe and to profound admiration. Man's mind has never conceived of a machine half so subtle and delicate, nor half so sturdy, efficient, and capable of satisfactory function in the face of almost overwhelming odds of excess and disease. The story of the adaptive phases that are observable in the circulatory system in health will be told in a later chapter; here we are concerned merely with the mechanism of adaptation and its relations to the heart and the blood vessels.

Healthy muscle possesses what is called tone, that is, a state of continuous slight contraction that keeps it in readiness to perform grosser movements at the behest of the nerves. A muscle without tone will not respond to stimulation; naturally, such a condition never occurs in healthy living muscle,

although the degree of tone may, at times, vary a good deal. The condition is analogous, in a way, to the tenseness of the sprinter at the tape as he awaits the sound of the starter's gun. The tone of all musculature is maintained by the continuous discharge into it, by way of the nerves, of feeble impulses from the nervous centers. In the blood vessels, the term tone is transferred in a rather loose way from the description of the condition of contraction in the muscular layer of the vessel to the condition of the vessel itself; thus, for brevity's sake, we speak of the tone of a vessel or, in a still broader sense, of vascular tone throughout the circulatory system. Obviously, an increase in tone means a decrease in the size of the vessels, and vice versa. Since heart and vessels have no outlet except into each other and therefore form what is called a closed system, it is evident that a contraction of the vessels of the system means a diminished capacity in the system as a whole. The converse, however, is much more important: with lowered vascular tone and dilatation of the vessels the capacity of the system is enormously increased. Recall the large disparity between the total cross

section of the arterioles and that of the aorta; and remember that variations in tone are most marked in these same arterioles; and it will be obvious at once that a very slight change in tone must involve a considerable change in the general vascular capacity.

The relation of the volume of blood to the capacity of its containing vessels may now be considered. It will be recognized, of course, that the circulation cannot be maintained without pressure any more than water will flow through a system of pipes without pressure behind it. Hydrostatic pressure, of course, would remain, even if the pumps should fail; but this is just another way of saying that gravity will cause the water or the blood to seek the lowest level in the system and remain there. The blood volume changes but little, if at all; any such descent of blood, therefore, in obedience to gravity and unopposed by vascular tone, would quickly leave the higher parts of the body devoid of sufficient blood to carry on their functions. Under such conditions life would very quickly cease. Rabbits die when suspended by the ears for a period of time; since their vascular

tone when they are suspended is not strong enough to oppose the force of gravity, the blood collects more and more in the lower portions of the body and leaves the brain without sustenance enough to support life. In such cases most of the blood collects in the atonic vessels that feed and drain the organs of digestion in the abdomen. During their active period of work these digestive organs require an enormous quantity of blood flowing through them not only to support their activity but to carry away the products of digestion to be delivered to the rest of the body. Accordingly, the network of vessels in the digestive organs is particularly rich and the vessels themselves are of relatively large size. It has been frequently stated and accepted that these vessels, if they were to be deprived of tone, would attain to a capacity that would hold all the blood in the body, so that it is theoretically possible for a person to bleed to death into the veins of his own abdomen.

Against such a fatality, the body has a bulwark in the phenomenon of tone. It is the province of the blood vessels to contract upon the contained blood not merely to that degree at which the blood

exactly fills all the vessel spaces throughout the body but to a further degree at which the blood is actually put under pressure. The process is exactly similar to that of filling a rubber ball full of water, sealing the opening, and squeezing the ball. The water within is then under pressure and it will squirt out if a hole be punched in the ball, just as blood will flow out of the circulatory system if a vessel be cut. It is this pressure, exerted by the heart and the contraction of the walls of the blood vessels upon the contained blood with varying intensity, that we speak of as "blood pressure." We shall attempt to follow the fluctuations of this pressure in health and in disease and shall try to determine what bearing changes in blood pressure have upon the maintenance of health.

CHAPTER III

THE FACTORS CONCERNED IN THE PRODUCTION, MAINTENANCE, AND ADJUSTMENT OF BLOOD PRESSURE

Of the several factors that contribute to the maintenance of blood pressure in the circulatory system the three most important are the contractile power of the heart, the elasticity of the arterial walls, and the peripheral resistance offered chiefly in the arterioles to the onward flow of blood. Other factors enter, such as gravity, barometric pressure, viscosity, and total quantity of blood; but they are of secondary importance and need not concern us here.

The three main factors are so intimately interrelated and so finely adjusted one to another that it is scarcely possible to describe one without reference to the others. But certain salient facts stand out and may be concisely stated. The heart, for instance, is the prime mover of the blood and the principal source of blood pressure. Without

some applied energy the blood would come to rest in the most dependent parts of the circulatory system under no pressure except that produced by gravity. But with each heart beat blood is forced into the arterial side of the system, resulting in an increase of pressure there and a decrease of the pressure in the veins behind the heart. If no other force were considered and no resistance were offered to the onflow of blood through the arteries, the arterioles, the capillaries, and the veins, back to the heart, the intermittent rise of pressure with each heart beat would be distributed equally through the circulation and the pulse beat would travel the whole route and reappear at the heart on the venous side. Such, we know, is not the case, for there is no pulse in the veins. The reason for this has been discussed in Chapter II. There we pointed out how, through branching of the arterial tree, the bed of the blood stream widens as its distance from the heart increases, permitting an ever slower and calmer flow of blood; and at the same time we tried to show how the elasticity of the vessel walls damps the pulse wave until it becomes lost in the arterioles and capillaries, just as

wavelets on the shore of a lake are lost amid the yielding rushes. Now still another conception must be added. Even in the generous width of the bed of the smallest arteries the blood is not allowed to flow on unimpeded. The tone of the arteriolar walls is a state of continuous mild contraction, so that within the arterioles the blood is always under some pressure. These small vessels stand as gates at the outflow of the blood from the arterial system; these gates oppose the outflow to some extent, and thus antagonize the action of the heart at the other end of the arterial system. The heart forces blood into the arteries; the arterioles oppose its free escape from them. Between the two, arterial blood is accordingly kept continuously under tension; in other words, "blood pressure" is created and maintained.

We dare not dismiss the subject of blood pressure, however, with a mere account of the general factors concerned in its creation and maintenance. We must discuss also its phases and variations, of which the simplest are evidently those occasioned by beats of the heart and the intervals between them. The blood pressure will obviously reach its lowest point ("minimal pressure") during

diastole (rest period) of the heart and after the pulse wave created by systole (contraction period) of the heart has passed through the arteries and died out in the smaller arterioles. The pressure then becomes stationary at its low point for a moment until another systole sends another surge of blood into the arteries. As the pulse wave passes any given point the pressure rises there again to its high point ("maximal pressure"), only to fall once more as the wave passes beyond it. Thus there is a fluctuation of pressure from minimum to maximum and back again with each cardiac cycle. Obviously there must be many levels of pressure during systole as well as during diastole. The high point of blood pressure is called the "maximal systolic pressure" and the low point the "minimal diastolic pressure." For the sake of brevity such high and low points are often referred to by physicians as "systolic pressure" and "diastolic pressure," respectively, without the use of the qualifying adjectives.

If the flow of blood were through rigid tubes instead of elastic tubes the maximal systolic pressure would be much higher than it is really found

to be, and would be, except for diminution through friction against the walls of the vessels, about the same as that within the heart during its contraction. Again, were it not for the arterioles, which prevent free egress of blood from the arteries to the veins, the diastolic pressure would fall to zero. Just as the arterioles maintain the diastolic pressure at a point above zero, so some agency must be present to absorb some of the energy of the heart's beat and to prevent the systolic pressure from rising too high. This agency is the elasticity of the vessel walls. Each time the heart throws a quantity of blood into the aorta, that vessel yields to the increased pressure by undergoing dilatation. As the pulse wave passes along and spreads into the arterial branches, the vessels enlarge for a moment to permit its passage without damage to themselves, exactly as the bulge slowly progressing down the length of a snake's body denotes the passage of the latest unfortunate mouse. A finger resting long enough upon the reptile's body would become aware of the passage of this slow wave, just as the finger on the artery at the wrist is aware of the far quicker passage of the arterial pulse wave. The wave, or,

as it is commonly called when perceived by the finger, the "pulse," can be easily felt in the large vessels of the neck; less easily, though still plainly, in the smaller radial artery at the wrist; and ever less easily as still smaller arteries are selected for examination by the palpating finger.

Eventually, as we have seen, the wave becomes lost in the arterioles and capillaries. A small part of this loss is due to the "petering out" of the wave as it reaches the ever-widening stream-bed of the smaller vessels; but by far the greater part of the wave is stifled by the yielding of the arterial walls—damped out by it, as echoes in a concert hall are silenced by yielding felt. It is important to note that the damping process is not a suppression of the energy that originates in the heart beat, appears in the form of the pulse wave, and causes the rise of blood pressure; the energy merely undergoes conversion into another form, kinetic energy being transformed temporarily into potential energy. The rhythmic contraction of the heart is rather violent and the systolic pressure within its ventricles is too high to be withstood successfully by the smaller vessels. Not only must the high

pressure be toned down; but at the same time the pulse wave must be converted into a steady flow in order that the nutritional benefits of the blood to the tissues may be mediated through the capillaries. Precisely these conditions are realized through the agency of the elasticity of the vessel walls.

The larger arteries are something more, then, than mere pipes for the transmission of blood; they are also active agents in the circulation, having a definite mission to perform in addition to mere conduction. By yielding to the wave of systolic pressure by dilatation they convert most of the kinetic energy (the proportion has been estimated to be as high as 99 per cent) of the heart beat into latent energy. The latter, in its turn, comes into play as soon as the peak of the pulse wave has passed and the pressure begins to fall rapidly behind it. Because of the same elasticity that enabled the arteries to dilate without harm, they tend now, in the face of the falling pressure, to return to their usual size; and in so doing they exert added pressure upon the contained blood. It is very likely, although not yet proved, that the

musculature in the vessel wall is stimulated at the same time and adds its "squeeze" to that of the elastic fibers. In response to this added pressure the blood tends to move and since its return to the heart is blocked by the aortic valves, it finds its outlet toward and through ever smaller arteries and the capillaries. In so far as the action of the elastic fibers shares in this result, some, if not all, of the latent energy stored by the vessel walls as the pulse wave passes is now returned as kinetic energy; thus the larger arteries come to share with the heart the burden of imparting forward motion to the blood stream. The enormous importance of this physiological arterial supplement to the work of the heart will become evident when we enter upon a discussion of the conditions that are associated with diminution or loss of the elasticity of the vessel walls; for we shall see that then upon the much-enduring heart there has been placed an added burden that sooner or later results in impairment of that organ's efficiency.

In some respects, the work of the hydraulic ram is a good illustration of the mechanical action of the arterial circulation. In a ram water is forced

intermittently (as by the heart beat) into a chamber partly filled with air. The air is compressed, damping some of the inrushing energy of the water, just as elasticity of the vessel walls damps some of the heart's energy. Water flows out of the air chamber of the ram against the resistance of the column of water in the pipes that leads up to the tank, just as blood flows onward in the arteries against the resistance of the arterioles. The movement of the water, like that of the blood in the arteries, is of two kinds; first, a sudden onward lunge due to the intermittent delivery by the pump of a large quantity of liquid; and, second, when the lunge is over, a slower, more steady forward motion, which is imparted by the pressure of the elastic air, the latter pressure corresponding to the contraction of the elastic and muscular fibers of the blood vessels. If the delivery pipe of the ram be long enough, the lunge will eventually disappear so that the flow becomes steady, just as it does in the human circulatory system.

To complete the picture of the variations in pressure in the arterial system during one cardiac cycle, a third factor must be considered, namely,

variations in the peripheral resistance offered by the arterioles. The rise of the blood-pressure curve is, of course, rapid, since the heart delivers its blood suddenly to the vessels; the fall is comparatively slow, due partly to the prolonged action of the elastic walls of the arteries and partly to the obstruction of the outflow offered by the arterioles. If it were not for friction of the rather sticky blood against the vessel walls, friction which eats up a good deal of energy, the fall in the pressure would be exactly equal to the difference between the energy represented by the pressure of the blood in the left ventricle during systole and that represented by the pressure in the arterioles and capillaries. With suitable allowance for the element of friction, the transformations of energy that actually take place are easily accounted for. The low point of the pressure curve, when measured, yields the figure for the minimal diastolic pressure. We have seen that the systolic pressure is determined by the force and frequency of the heart and the condition of the arterial walls; and we can now see that the minimal diastolic pressure point is determined by the amount of resistance

offered by the arterioles to the oncoming blood. The minimal pressure is the point at which the falling blood pressure becomes stationary toward the end of diastole; not until the advent of a new impulse from the heart does the pressure within the arterial system rise again.

Considerable space has been devoted to the parts played by the heart and the larger arteries in the production and maintenance of arterial blood pressure and the rôle of the resistance offered by the arterioles has perhaps been sufficiently indicated. We have seen that the systolic pressure is highest in the ventricles of the heart during systole and falls gradually as the smaller arteries are reached. A still greater fall occurs beyond the constriction-system of the arterioles, and in the thin-walled capillaries the blood pressure becomes very low indeed. We are not here particularly concerned with the pressure levels in the veins, except to note that whenever dilatation of arterioles and capillaries occurs, pressure is lowered on the arterial side of the circulation and raised on the venous side. The return flow of blood to the heart through the veins is accomplished not so much by pressure

behind it as by certain other mechanical factors. The veins in the lower part of the body, for instance, are provided with valves to prevent back flow. Again, many of the veins are rather near the surface of the body and are subject to muscular pressure during bodily movements; such pressure from without is easily exerted, since the veins have thin muscular and elastic coats and are easily collapsible, in contradistinction to the arteries, which always maintain their tubular shape. Blood pressure is lowest in the large veins; indeed, it falls to and below zero in those large veins that traverse the chest, because within the chest, owing to the contraction of the diaphragm in the act of inspiration, there is created a partial vacuum, which accounts both for the entrance of air into the lungs and for the development of a negative pressure within the large veins.

Thus far we have given a mere outline description of the three main factors responsible for the existence of the blood pressure; the interrelation of these three factors is another story. This leads us to a consideration of some of the functions of the vegetative nervous system, for it is this system

that stands guard over fluctuations in blood pressure and correlates the various influences that affect it. A description of the complex anatomy of the vegetative nervous system is a matter for a large medical textbook; but, we are here concerned only with those parts of it that cause contraction or dilatation of the blood vessels and those which increase or diminish the rate of the heart beat, and we may disregard those parts of it that govern the functions of the internal organs.

The vegetative nervous system is connected with the central cerebrospinal nervous system (brain, spinal cord) and with the nerves of that system which carry sensory impulses to it and motor impulses away from it to the skeletal muscles; and each part of the vegetative nervous system is connected by many cross branches with other parts of the same system. From the brain it receives impulses that arise during emotions and moods or on the reception of impressions through the "five senses"; thus fear, anger, disgust, nauseating smells, terrible sights, and the like, may come to have an echo in variations of the blood pressure. Through other parts of the cerebrospinal nervous system it derives

impulses dependent on stimulation of the organs of cutaneous, muscular and special sense and others dependent upon stimulation of the musculature. And the vegetative system itself is related especially to what goes on not only in the blood vessels but also in the internal organs and the secretory glands. The vegetative nervous system is thus, as it were, the Associated Press of the body, with correspondents in every nook and cranny of the organism; it is a great correlating agent of all the bodily functions.

As far as the circulation is concerned, the vegetative nervous system carries at least two sets of fibers, known respectively as "vasoconstrictor" and "vasodilator" fibers. The former stimulate the muscular coats of the blood vessels to contract, whereas the latter cause the vessels to dilate. The vasoconstrictors are responsible for the maintenance of tone in the vessels and the impulses to that end emanate from the brain itself. The connections and mode of action of the vasodilators are less well understood, though their existence is beyond doubt. In the distribution to the heart, these two classes of fibers have their analogues in the accelerator and

inhibitory nerves, which respectively hurry or slow the heart's action.

Enough, perhaps, has been said of the significance of the three main factors concerned in the production and maintenance of blood pressure to render unnecessary here anything more than a brief catalogue of the mechanisms through which these factors are interrelated through the mediation of the vegetative nervous system. The subject will crop out again and again in the pages that follow. The vegetative nervous system may raise the blood pressure by hurrying the heart, which then pours more blood per minute into the arteries; by increasing the tone of the heart muscle and hence the force of its contraction, with a similar result; or by increasing the tone of the muscular walls of the vessels and thus increasing the peripheral resistance in the arterial system. These activities may exist in various combinations; usually, and especially in transient emotional states, all three come into play. Under long continued conditions of mental or physical stress and strain the increase in tone of both the heart and the arterial vessels may become more prominent, in which event the heart,

instead of adopting a permanently hurried rate, accommodates itself to the increased work by growing literally larger and more powerful. Other parts of the vegetative nervous system lower blood pressure by slowing the heart and by diminishing the cardiac and the vascular tone. If the great arteriolar bed suffers, in general, a marked lowering of tone, as in a common fainting attack, in surgical shock after anesthesia, or after a severe injury, the sympathetic system (a part of the vegetative system) tries to maintain the pressure by hurrying the heart, in order to keep full the arteries, which are being depleted by a too rapid draining away of the fluid through the relaxed arteriolar gates. Again, after a heavy meal, the heart is stirred to more rapid action, for otherwise there would be a fall in blood pressure because of the fact that the arterioles in the digestive area (the most extensive arteriolar bed in the body) relax during digestion in order that more blood may flow through the active organs. Such physiological variations in pressure are seldom demonstrable with instruments, for the very good reason that the sensitive vegetative nervous system "catches"

the tendency to change before it has become pronounced and takes up its regulatory function of maintaining the pressure at a fairly uniform level. As a matter of fact, during digestion, the blood pressure usually rises a little, because the vegetative system in its regulatory capacity not only counterbalances the tendency to fall but actually overcompensates a little.

A compensation that is even more remarkable is observable among the vasoconstrictions and vasodilatations of the different arteriolar areas of the body. A lowered tone in one arteriolar area may be neutralized by a rise of tone in some other so that the general blood pressure is not changed. After eating, for instance, one feels a cold wind more than before, because the tiny vessels in the skin are sympathetically constricted, squeezing their blood out to some extent in order that it may be diverted to the active area of digestion. The relative lack of warm blood in the skin area is telegraphed to the brain by the sensory nerves and interpreted there as a sensation of cold.

Many intricate adaptations within the domain of the blood pressure functions might be mentioned.

They are all for a definite purpose, namely, the maintenance of efficient blood pressure. Maximal adaptability presupposes the existence of a heart adequate to its work, vessels with unimpaired walls, a normal degree of tone throughout the circulatory system, and a state of general physical and mental health that enables a normal vegetative nervous system to make the quick responses and to bring about the adaptive changes that are continuously being demanded.

CHAPTER IV

"NORMAL" BLOOD PRESSURE; AND METHODS OF MEASURING BLOOD PRESSURE

THE good, old, Latin word "normal" has come to be much abused of late—and that, by its friends. In old Italy "norma" meant a rule, a pattern, a carpenter's square—a measure by which other objects could be accurately delimited; in modern parlance its edges have been chipped and its corners rounded until it no longer represents anything so definite as an inch or a right angle. It has been applied to processes and abstractions. It, so to speak, sits in judgment over matters as diverse as the rainfall in Peru, the number of passengers in the subway at 5 P. M., or the count of red corpuscles in a cubic millimeter of blood. But it must always be remembered that the so-called "normal" is arrived at through a series of observations of individual events.

The method of ascertaining the "normal" can

best be appreciated if we turn to concrete examples for illustration. Take, for instance, the temperature. The newspaper tells its readers that the temperature for the preceding month was so many degrees above or below "normal." The statement is merely the result of the consideration of daily observations of air temperature during the same month extended over a period of years. All the fluctuations, reduced to a mean, yield an average figure, which is held to be the "normal" for that month. But no one believes for a moment that there will ever come a time when the temperature for that particular month will always conform strictly to that norm. Nor is any one disturbed about the thermometer if it shows variations of a few degrees to either side of the established norm. The man who got excited over an unseasonable drop of temperature and cried to his neighbors that the world was about to freeze up would be laughed to scorn. In other words, the normal temperature is recognized as merely the average temperature from which variations may be expected; and unless these variations are extraordinary they receive but little attention. As a matter of fact, the whole range of

variations of temperature in a given place and on a given date (as determined over a period of years) expresses the "normal" temperature for that place and date more accurately than any single figure can.

The example of the air temperature as measured by the thermometer is fairly simple, for the factors that govern temperature are fairly well known, are relatively few in number, and are likely to interact with one another in the same manner time after time. In more complicated examples, the determination of the normal may be much more difficult. As the complications increase, the idea of ascertaining a "normal" as a point must be given up. Thus, it cannot be said with truth that the "normal" price of eggs is forty cents a dozen; although it might be true that in Washington County, Maryland, in June, the normal price at the farm is forty cents, providing hawks, rats, and foxes are not too numerous, the cost of hen-feed is moderate, and the gapes are not too prevalent. But it would be much nearer the truth to say that the "normal" range of prices of eggs at that time and place was from thirty to fifty cents; any price outside those limits might reasonably be said to be "abnormal."

Exactly the same reasoning applies to "normal" blood pressure, but to a much greater degree: for wherever a function of a living organism becomes the subject for the determination of a norm, the factors influencing the position of that norm are found to be so numerous, so diverse, and so little understood, that it is folly to put the finger at any one spot and to assert that there is the normal. Age, sex, inheritance, general physical health, weight, height, time of day, time since eating, climatic conditions, position of body, state of mind, and a thousand other things may affect the blood pressure. It is constantly varying up and down the scale, in accordance with bodily needs and conditions. "What is a normal blood pressure either for the individual or the species has never been and never can be determined, because the pressure must vary according to the calls of the system for more or less fresh blood." [1]

Let us, then, along with the original investigators, disabuse our minds of the old Latin meaning of "normal" as a definite, unchanging rule, or meas-

[1] Moschcowitz (E.). "Pathology of Hypertension," *Jour. A. M. A.*, Chicago, 1922, lxxix, 1196-1200.

ure, and think of it rather as an elastic expression of a *range of values* that do not vary far enough away from the ascertained average to be called abnormal. Better still, give up the use of the word "normal" altogether as applied to blood pressure, and substitute for it the term "average." To the man who is worried about his blood pressure, such a substitution very often brings a sense of relief. "Average" impresses the man in the street as a less strict term than "normal"; if he learns what average blood pressure is he will not shy in alarm at the discovery that he experiences moderate variations of pressure; and he will not assume that every man's pressure must be the same as his neighbor's. Besides, the term "average" is more accurate than "normal" for general application, for what is a "normal" pressure for one man may be quite "abnormal" for another. Of course, it is accurate to speak of normal variations in pressure; but the use of the term "average" blood pressure connotes that such variations may occur and still be within normal limits.

Blood pressure is commonly measured, in this country, with an instrument called the sphygmoma-

nometer, so named because it measures the pressure of the pulse. It consists of a non-elastic arm-band or cuff (of leather or of stout cloth) within which is contained a flat but distensible (rubber) bag. The bag is connected with an air-pump (usually a rubber bulb) and with a pressure indicator; the latter may be an upright tube containing mercury, the height of the column of mercury in millimeters indicating the pressure; though more often an aneroid indicator is used. In either case, the reading of the pressure is in terms of millimeters of mercury. In practice, the arm-band with the flat rubber bag interposed is fixed firmly round a limb (usually the arm just above the elbow). Air is then pumped into the bag, which, against the resistance of the rigid arm-band, exerts its pressure on the arm, the amount of the pressure being registered by the indicator. It is evident that the soft tissues of the arm will yield to this pressure, and that, among other structures, the large artery in the arm (the brachial artery) will be compressed. When the pressure in the cuff rises to a level equal to that existing within the artery, the vessel will collapse and the flow of blood through it will be

shut off; simultaneously, the pulse at the wrist will disappear. The pressure in the cuff is usually quickly raised to a level somewhat above that necessary for the obliteration of the pulse and then allowed slowly to fall. Meanwhile a stethoscope is placed over the artery at the bend of the elbow. At first nothing can be heard; but as the pressure falls slowly, the listener becomes aware of a sharp, snapping sound, denoting the passage past the constricting cuff of a bit of the pulse wave. The pressure in the cuff must now be equal to the maximal systolic pressure within the artery; the degree of pressure exerted is then read on the indicator and noted as the "maximal systolic pressure." Deflation of the cuff is then further continued, with variations of the sounds heard at the elbow until at last they practically disappear. At this point, or at a point just preceding when there is a sudden and marked change in the sounds, the pressure in the cuff is just equal to that maintained in the artery between the successive pulse waves, and so is a measure of the "minimal or diastolic pressure" within the artery. This figure is also read on the indicator and noted alongside that for the systolic

pressure. The difference between the maximal systolic pressure and the minimal diastolic pressure is called the "pulse pressure."

An enormous amount of research has been carried out to determine the average figures for maximal systolic and minimal diastolic pressures in healthy human beings. Wiggers[2] sums it up well when he concludes that, in adult life up to middle age, the systolic pressure ranges from about 110 to about 135 (millimeters of mercury); and the diastolic from about 70 to about 100 (with a usual range of from 70 to 90). After middle life, the systolic figure is usually a little higher, perhaps by 10 mm., though the diastolic changes but little in health. In children, the pressures are lower than in adults. The pulse pressure (systolic minus diastolic) is thus usually about 35 to 50 mm. of mercury in adults.

Woley gives the following figures based on the examination of 1,000 healthy individuals:

Age..	15-30	31-40	41-50	51-60
Average systolic pressure...	122	127	130	132

[2] Wiggers (C. J.). *Modern Aspects of the Circulation in Health and Disease*, Philadelphia, Lea & Febiger, 1923.

Fisher, working with life insurance statistics, reports slightly higher figures.

Practically, then, the answer to the oft-posed question of what "normal" blood pressure is should perhaps be that there is no "normal," but that persistent systolic pressures below 110 (hypotension) and above 135 (after middle life, above 145) (hypertension) are to be looked upon with suspicion. Similarly, persistent diastolic pressures below 70 (hypotonus) and above 100 (hypertonus) should be investigated.

The diastolic pressure, it will be remembered, represents the amount of "squeeze" exerted by the arterioles upon the volume of blood in the arteries. Although, in health, it is constantly varying in different parts of the body, an increase in one part is usually compensated for by a decrease in another, so that the sum total is kept fairly constant, despite the fact that the blood stream is deflected now to this organ and now to that. The diastolic pressure, as estimated by the sphygmomanometer, consequently varies only a few points measured either by day or by night. The systolic pressure, on the other hand, depends largely upon the activity of the

heart, which may vary a great deal in response to physiologic needs. It is common knowledge that the pulse rate changes easily with changing physical or mental states. We are not surprised, therefore, to find that the systolic pressure shows greater fluctuations than the diastolic during the daily twenty-four hours. It is true, however, that both systolic and diastolic pressures usually rise and fall together, though not to the same extent. It may be said, with rough approximation to the truth, that the diastolic pressure is a fair measure of the condition of peripheral resistance in the arteries and arterioles (narrowing the caliber due to tonic contraction or to organic narrowing) and that the systolic pressure is a fair measure of the work of the heart over and above the resistance offered in the peripheral vessels. In any estimation of conditions obtaining in the circulatory system, it is most important, therefore, to be in possession of knowledge of both the systolic and the diastolic pressure; indeed, some excellent medical men attach more importance to the diastolic figure than to the systolic, believing rightly that it reflects the state of the arteries better than the systolic pressure possibly can.

CHAPTER V

INFLUENCES AFFECTING BLOOD PRESSURE IN HEALTH

It may be that enough has been said to make clear several facts: (1) that blood pressure far from being an abnormal thing is essential to the circulation; (2) that it is, therefore, normally present in every living human being; and (3) that there is no such thing as a single "normal" level of blood pressure, but rather a normal range of blood pressure levels within which fluctuations may be expected. The blood pressure is essentially an adaptive mechanism; and this point must be thoroughly grasped if we are to understand at all well the changes in blood pressure that accompany various diseased conditions. In fact, the only sane way to approach the entire subject of the blood pressure is through the realization that the changes of pressure occur in answer to demands of one kind or another made by the body upon the circulation.

Increased blood pressure, even when marked, is not to be looked upon, in the last analysis, as bad in itself, but only as a circulatory condition brought about in answer to some abnormal condition existing elsewhere in the body. True it is that high blood pressure, if prolonged, will give rise, in its turn, to disturbances of other bodily functions, as we shall have occasion to see later; but at the beginning of its rise above the healthy average for the age and sex it is the expression of trouble somewhere else rather than the cause of such trouble. If we should begin, here, to comprehend the principles that underlie the treatment of patients exhibiting high blood pressure, we must first make sure that we think of blood pressure in health as a beneficent phenomenon, as fluctuating within fairly well-defined limits, and as serving to adapt the flow of blood to the bodily needs. Since the body is never completely at rest (for even in sleep many of its organs must keep at work), and since it is now one organ and now another that demands change in its blood supply, it is not hard to see how alert the mechanisms that govern the blood pressure must always be. Day and night, adaptations in

blood supply must be made, and made swiftly, if health is to be conserved.

Perhaps the easiest way to visualize these swift and frequent changes in blood pressure is to follow an imaginary person, Mr. X, through a period of twenty-four hours. To bring him nearer to us, let him be one of our personal friends. Let us suppose that he is just going to sleep as we begin to observe him. In from one to two hours his sleep should be its deepest, and his maximal (systolic) blood pressure will fall perhaps as much as twenty points. From that time on until early morning, say at about 5 A. M., it will rise again slowly, but not to its average level for waking hours. The minimal (diastolic) pressure will change but little. Both maximal and minimal pressures will probably fall slightly every time he draws a breath, and will rise again as he exhales.

When he gets out of bed, thus changing from a recumbent to a standing position, the blood will tend to gravitate into his legs and into the huge capillary bed and large veins of his abdominal organs; if this were to occur to any marked extent, the larger arteries would be more or less drained

of blood, and the pressure in them would fall. But an increase in arteriolar tone will prevent the outflow and the depletion of the larger arteries, and, as a result of more active contraction of the arterioles, the blood pressure will even rise a few points. Sometimes, indeed, after long illnesses or in other weakened conditions, the vegetative nervous system does not respond quickly enough, and at first a little too much blood is allowed to run away from the arteries; the brain, being, in this case, the organ farthest from the ground, feels the deprivation first, and registers it in the form of a dizzy sensation.

Our imaginary friend next takes his "setting-up" exercises, and if he be a healthy young adult, he may go through with them very vigorously. The muscles will call loudly for an increased supply of blood; the heart will respond with a quickened beat, and so will raise the systolic blood pressure, since it will pump into the arterial reservoir an increased amount of blood per minute. Simultaneously, the arterioles and capillaries within the active muscles will dilate to allow more blood to reach and nourish the muscle fibers. The fall of arteriolar tone thus

occurring will tend to lower the general blood pressure; but in this case the decrease of arteriolar tone will probably be more or less localized within the muscles then actually in use, whereas there may even be an increase of arteriolar tone in other parts of the body in compensation, to the end that the increased general pressure may be maintained and a good flow of blood to the muscular masses so insured. When the morning "stint" has been finished, the maximal blood pressure may have risen thirty or forty points or even more, and the minimal from ten to twenty points. If new and complicated exercises that demand close attention are tried, the rise will be greater—perhaps as much as sixty or seventy points for the maximal and as much as thirty or forty points for the minimal pressures. If, again, the movements have demanded a great deal of straining, with diaphragm set and mouth closed, the maximal pressure may have risen momentarily to levels that are rare even in diseased conditions. A maximal blood pressure of 200 millimeters or over may be registered during such strain. The minimal pressure will rise, too, but never so far beyond its average level.

Breathless, perhaps, X throws himself into an easy chair for a moment's rest. The pulse rate falls to normal in from two to three minutes, and the pressure figures come down to X's usual average though a little less quickly.

When he has "regained his breath" and his pulse rate and blood pressure are again "normal," X takes his "shower." If this be of warm water, we shall find that the arterial tone undergoes increase, resulting in a small rise of the minimal pressure (only a few points), an increase of heart rate and, as is usual, a rise of the maximal pressure greater relatively than that of the minimal. When, towards the end of the shower, he turns on the cold water, the minimal pressure will probably remain somewhat elevated, though the maximal pressure and the pulse rate will fall.

While he is dressing, X may begin to think of the day's work in store for him. He will remember, perhaps, an especially perplexing problem that is to come up during the morning, on the solution of which important consequences hang. If he be worried over the outcome his maximal pressure will rise somewhat as a result of his emotional state.

Breakfast over, finding that he will be late for his first appointment, he hurries to the garage, jumps into his automobile, and starts off for the office at top speed. This anxious mental state will be reflected in his blood pressure and particularly in the maximal systolic figure. At a cross street another motorist, clearly without the right of way, hurtles into him and tears off a fender. An altercation ensues, during which X becomes ever more angry. Again there will follow a rise of systolic (maximal) blood pressure, due largely to an increase of the force and the rate of the heart's contractions.

Here we may pause for a moment to consider the interesting effects of strong emotions upon the blood pressure. Some investigators have held that certain emotions, pain and fear particularly, are depressing in themselves; but, as Darwin long ago pointed out, "a man or animal driven through terror to desperation is endowed with wonderful strength, and is notoriously dangerous in the highest degree." In animals and in primitive man the strong emotions were but preliminaries to quick and violent action. Fear even now means tendency to fight or

flight, and anger means desire to punish or to slay. The prospective muscular activity will demand an increased flow of blood, and that will depend upon stronger and faster heart action and upon an increased maximal blood pressure. Even though modern man has learned to control himself during fear and may neither fight nor fly, the physiological preparation for fighting or flight remains and his blood pressure becomes accordingly elevated.

After luncheon X has a chance, perhaps, to sit down for a few moments, or better still, to take a short nap. If so, as a result, his maximal blood pressure, which in addition to all the fluctuations noted, has been showing a slight but steady rise throughout the waking day, will now fall a little, perhaps as much as from ten to fifteen points. But when he again goes to his desk and plunges into the complex details of his "paper work," this mental activity will be reflected in a moderate rise of his maximal pressure.

The peak of the gradual daily rise of blood pressure will be reached about five o'clock in the afternoon, when, as a rule, fatigue begins to set in. Fatigue always brings with it a decline in the blood

pressure, not in the maximal pressure only, but also in the minimal. X will obviously have become tired with his day's work by this time. Fortunately, it is now time to close the office and to go home with a good dinner in prospect.

Now a crucial time of the day for him has been reached. We have neglected mealtime up to this point, in order to emphasize the effect of the largest meal of the day, for this is a most important influence upon the blood pressure. Overloading the digestive tract is one of the great hygienic sins of the average American. What with soup, a heavy meat with thick gravy, several vegetables, a salad, a rich dessert, and a cup of strong black coffee (that prince of heart stimulants), our friend X may find himself at the end of the meal uncomfortably full and disinclined to any activity, either of his body or of his mind. Perhaps he may even drop off to sleep over his evening paper. If he thinks of it, he will probably find that his heart is beating at a faster rate than usual and will, perhaps, feel a little difficulty in getting a full breath. He lays this to the full state of his stomach, and to some extent correctly; but more than fullness of the

stomach is concerned. The stomach and the intestines have, by this time, become busily engaged in reducing the food taken during the meal to a variety of substances suitable for absorption and transmission to the temporary storehouses of the body. The digestion of food is not by any means a simple process. Waves of contraction pass over the hollow digestive organs and urge the food material forward through the alimentary tract; the muscular work involved in this is not inconsiderable. Besides chemical activity within the body is now at its height; digestive fluids must be secreted by the glands from the blood and poured out in profusion into the gastro-intestinal canal; and the prepared food-fluids must be passed through the intestinal walls and carried away from them by the lacteals and by the blood stream. There is thus an intense and continuous demand for blood and more blood for the vessels that supply the whole digestive tract. To fill the demand the great arteriolar and capillary bed of this tract, as we have seen, by far the largest single system of the sort in the body, must undergo dilatation in order to allow the passage of the unusual amounts of blood tem-

porarily required. We might expect that the blood pressure would be lowered as a result of this dilatation in the digestive domain; but, on the contrary, a rise ensues, for again compensatory changes in the arteriolar and capillary system occur elsewhere. The skin area, for instance, may be called upon for help, and we may find that as a consequence it misses the amount of heat that the usual volume of blood brings to it, and registers the lack as a feeling of mild chilliness, especially if the temperature surrounding the body be at all low. An even more potent factor in maintaining the blood pressure above normal during digestion, however, is the more rapid and more forceful action of the heart. The preponderance of the increased heart action over the dilatation of the capillaries in the splanchnic, or digestive, area is evidenced by the rise in maximal blood pressure. The minimal is little changed. The effect of active digestion on the heart is, then, much the same as that of muscular exercise.

Later in the evening, Mr. X goes to bed and to sleep; after an hour or two his blood pressure will be somewhere near the level of that obtained twenty-four hours earlier.

If Mrs. X be thought of as being of the same age and as healthy as her husband, her pressure will tend to be maintained at levels from five to eight mm. of mercury below his. If the two weigh more than they should, and especially if they be very fat, their pressure may be considerably above the average figure; and the heavier they are, the higher their pressure. If, instead of being Americans, they should be natives of the Far East, their average pressures would be 10 to 30 mm. lower than their western fellows; although if they should then emigrate to America, it would be found, after a time, that their pressures had risen some five points or more. Again, at times, when the barometric pressure is high, the blood pressure rises slightly, other influences being equal and with a falling barometer the blood pressure also tends to fall a little. If they should ascend Pike's Peak, by railway (to eliminate the factor of muscular work), both maximal and minimal pressures would be found slightly lower at the summit than in the valley below; though after a few days of residence at the top both pressures would return to about average levels.

If we could follow the blood pressure of either of our friends through life, we should of course find great differences in the pressure levels at various ages. Thus, according to the results of one series of investigations, in which some 2,300 observations were made, the blood pressure averaged 91.8/65.6 mm. of mercury (the numerator being the maximal, and the denominator the minimal figure) at 3 years, and 105.6/67.5 at 15 years.[1] And another series of investigations, in which the blood pressure levels in relation to body weight were recorded, yielded the following results:[2]

Weight	*Systolic blood pressure*
Infancy	75-90 mm. of mercury
30- 40 lbs.	95 "
40- 50 lbs.	100 "
50- 60 lbs.	107 "
60- 70 lbs.	112 "
70- 80 lbs.	116 "
80- 90 lbs.	122 "
90-100 lbs.	126 "

Thus it will have been made plain that every day, and throughout every day, the blood pressure,

[1] Judson & Nicholson. *Am. J. Dis. Child.*, 1914, viii, 257.
[2] Michael. *Am. J. Dis. Child.*, 1911, i, 272.

both maximal and minimal, is fluctuating in obedience to physiological laws and in answer to varying physiological demands; and that, therefore, no single level dare, dogmatically, to be called "normal." In a young, healthy individual, it will be found that the range of pressures during a single day may be from 110 to 170 (or even to 200 or more, under stress of violent exertion) for the maximal figure, and from 70 to 80 (or 85) for the minimal figure. This entire range is to be looked upon as "normal," when the various activities are considered. The "average" for the waking, resting periods might be about 125/70. This is the best answer we can honestly make to the question "What is 'normal' blood pressure?"

CHAPTER VI

ON SOME VARIETIES OF HIGH BLOOD PRESSURE AND THEIR CAUSES; RELATIONS TO HARDENING OF THE ARTERIES

High blood pressure is often spoken of as arterial hypertension. The high figures that were referred to in the previous chapter as occurring occasionally as normal results of physiological processes do not merit the name of pathological hypertension: first, because they are produced by normal mechanisms; and secondly, because they are merely temporary and not persistent. Hypertension as a pathological term applies to those high blood pressures that are the result of abnormal processes within the body and which are also more or less chronic or permanent. The term "hypertension" has, furthermore, been more expressly applied to a heightened maximum (or systolic) pressure, for the reason that this maximum pressure suffers greater deviation from the average than does the minimum (or diastolic). When the minimum pressure remains at a level higher than

the average, the condition is sometimes spoken of as "hypertonus," signifying that the fundamental tone of the arterioles is increased beyond the degree existent in health. It would seem best in a book like the present one to woo simplicity; "hypertension" will, therefore, here be understood to mean an abnormal and more or less permanent increase of maximum systolic, of minimum diastolic pressure, or of both.

The causes of hypertension are sometimes described as being either "functional" or "organic." These are rough-and-ready terms that have a certain practical value, though from the theoretical standpoint they offer great difficulties to exact definition. All through the realm of medicine a phenomenon is ordinarily spoken of as being of functional origin when it depends upon a temporary unbalancing of the physiological processes of the body. Thus, a green-apple stomach-ache is regarded as a "functional" disorder. There is no doubt that "abnormal" symptoms are present—that something is wrong. The trouble is not due to any gross change in the structure of the stomach, however, but rather to the way it works under an unusual stimulus. The

unripe fruit has induced an "upset" of the ordinary mechanisms of digestion, as a result of which the stomach can not carry on its usual work. Under dissection and examination by the microscope, nothing, perhaps, could be found *structurally* wrong with the stomach. The trouble is, accordingly, spoken of as functional; in the absence of "structural" change, the function can usually be brought back to its normal. In the case of disturbance due to the eating of green apples, nature adequately meets the situation; the offending contents of the stomach are removed, the gastric function returns to normal, and the episode is over.

But if pain and vomiting are due to some alteration of the stomach's structure, such, for instance, as an ulcer, then the case is quite different. Disturbances dependent upon such gross structural changes are described as being definitely "organic." Function suffers, of course, but the cause of the functional disturbance lies in an obvious and relatively gross change in the stomach machinery. This is a more serious matter for, even though the lesion may be healed by appropriate methods, a scar is likely to result, and the organic change will have

left its permanent mark. We can scarcely hope as physicians to see that stomach return to the same perfect state in which it was before the ulcer developed.

As a matter of fact, it is probable that there are no functional manifestations without some simultaneous structural changes. But in the functional disorders (so-called) as contrasted with the organic disorders (so-called) the changes are minute—of a physical or chemical order, rather than of an anatomical order of grossness.

The same considerations hold true for arterial hypertension. Some cases are called functional; and in them the blood pressure will return to average levels if the causes of dysfunction are removed. Other cases are called organic; they are due to some structural change in the heart, in the blood vessels or in other organs; and in these cases, though the process may be prevented from growing worse, it can seldom be got rid of entirely, nor, as a rule, can the patient hope to see his blood pressure return to its earlier levels and remain there.

When we thus separate these two classes of

causes of hypertension—the functional and the organic—we do not mean to form two entirely separate and mutually exclusive groups. On the contrary, as is so often the case in science when we attempt to classify delicate and mutually interdependent processes, these classes tend to run into one another. Though there are certain cases of hypertension that none would hesitate to set down definitely as functional, and certain others that would just as readily be designated organic, there are still more cases that are intermediate and partake of the nature of both the extreme classes, being partly functional and partly organic, or in the process of passing over from the functional class to the organic. It is very probable that functional hypertension should be looked upon as a symptom of the early stages of processes that may lead subsequently to organic forms of hypertension. With this preliminary warning that the classification of the chronic arterial hypertensions into functional and organic presents especial difficulties, we may pass on to an examination of the circumstances in which they are found to occur.

The functional hypertensions appear to arise in

association with certain persistent mental states or with intoxications in which some known or unknown poisonous substances circulate in the blood. The commonest of the causes to which high blood pressure has been attributed is the abnormal "wear and tear" of our modern life. We are proud of our traditional American "pep," and of the ability of the American "to get things done." If we can "go the other fellow one better," we do not stop to count the cost to us in the tense, driving hurly-burly of our days nor in the anxiety of our sleepless nights due to taking our worries home with us and to bed. The American business man is prone to think that he must not yield to relaxation if he is to "win out." There can be no intermission in his game. He will reach Athens, even if he die with the cry of "Victory" on his lips!

Though this new-world attitude has its excellences and is responsible for much of America's commercial greatness, it can be, and only too often is, practiced to an extreme. And it is a vast and hideous mistake when it is allowed to injure seriously the country's business and professional personnel. This result might have been anticipated

and it is, in fact, becoming increasingly evident in American life. For tenseness, anxiety, and fear are bad habits of mind—habits that sooner or later are inimical to the welfare of the body. Anxiety and worry involve an element of fear, and, as we have seen in a former chapter, fear and emotions allied to it condition unconscious preparations for either fight or flight, which in turn are accompanied by a rise of blood pressure in order to prepare the circulatory system for the expected strenuous work. Even though the necessity for violent muscular action should not be arrived at, the preparation for it remains the same. If normal intense mental concentration is accompanied by a normal rise of blood pressure, which falls again to average levels when the mental work is over, it is easy to see how abnormal mental perturbation, persisted in all day long and every day, might establish after a while a blood pressure that also is abnormal not alone in its degree, but also in its persistency. And this is precisely the result that is observed. The man of many affairs, who provides himself with no time for rest and relaxation, because he may feel and believe himself to be at the top notch of physical

perfection, would do well to bear in mind the subtle changes that may be going on within him. His wife, perhaps equally busy and beset by all manner of social and household worries, may be in similar case. It is pleasing to see the return to normal or to nearly normal, so far as blood pressure goes, of such persons as are sane enough to take a physician's advice when he recognizes their faults of hygiene and prescribes rest and moderation in activities or even complete withdrawal from affairs for a time.

Some of the instances of high blood pressure without organic changes unhappily do not seem to depend upon psychic factors only. In them, the functional hypertension may increase without apparent cause, year by year, despite treatment. Much has been written about this type of hypertension. One great Englishman has thought the group of cases sufficiently distinct to warrant their inclusion under the special name, "hyperpiesis." The process is usually assumed to depend upon the presence of a noxious substance, elaborated somewhere in the body, which circulates in the blood and stimulates the arterioles to contraction, either by

acting upon the vasomotor center in the brain or by acting directly upon the arteriolar musculature. As a result of the increased resistance to outflow through the arterioles, there is a rise of the minimum pressure. To overcome this increased resistance to outflow from the arterial system, and so to maintain the integrity of the circulation as a whole the heart must do a larger amount of work. And as we have seen, increase of the heart's effort, whether this consist of a more frequent rate of contraction or of an increased force of individual beats, leads to a rise of the maximum pressure. Thus both minimal and maximal pressures reach higher levels.

Again, hypertension, in the sense of an increase of blood pressure that is not in response to any normal stimulus, may follow the use of certain drugs. Caffeine, in coffee, certainly raises the pressure temporarily; so does the nicotine in tobacco; but it has not been proven that even the long-repeated use of these poisons results in more than temporary rises of the blood pressure. Alcohol, also, has been incriminated as a cause of high blood pressure; but here again, the proof is lacking.

Though men or women who have used alcohol to excess frenquently exhibit hypertension, it is quite possible that the changes that underlie it may have been brought about by concomitant faulty habits of hygiene quite as much as by any direct action of the alcohol. Adrenalin, secreted normally by one of the glands of internal secretion, is a powerful hypertensive agent; but its action is short-lived. The theory that hyperpiesis is due to a continuous over-secretion of this substance has not been upheld by experiment. Workers in lead, mercury, and zinc often develop high blood pressure, due, however, to organic changes in the arteries and kidneys induced by the long-continued action of these poisonous metals.

Women sometimes show a functional hypertension just before the menstrual periods and often also when the "change of life" is beginning. Here the functions of the glands of internal secretion are almost certainly involved, but the precise relationship and the mechanisms of their action are not yet known. It should be added that the internal secretions may have something to do with hyperpiesis in men as well as in women, and also that they may

affect the blood pressure in women at times other than those of menstrual disturbances.

It is fascinating to speculate upon what part heredity plays in these functional hypertensions. Someone has said that "man is physically as well as metaphysically a thing of shreds and patches borrowed unequally from good and bad ancestors, and is, therefore, a misfit from the start." Certainly, some persons are more able than others to stand great and long-continued strains without showing signs of wear and tear; and there is good reason to believe that some of us possess arteries that are endowed with a better quality of tubing than do others. Individual nervous make-up is pertinent, too. The arterial system responds readily, as we have seen, to nervous influences, and everyone knows that there are great individual differences in nervous excitability for which heredity may be in large part responsible.

So much for the groups of hypertension that are not associated with any demonstrable organic change anywhere in the body. These groups stand at one end of the whole series of hypertensive disorders. The middle group is confused, as we have

said above, so that it will be best to skip it and to turn at once to an examination of well-defined cases at the other end of the series, where we find hypertension definitely associated with recognizable structural (that is to say, organic) changes in various parts of the body.

The most important of these changes are found in the walls of the blood vessels themselves. Under certain conditions, to be mentioned later, a real alteration occurs in the structure of the walls of the arteries. The elastic elements disappear to a considerable extent and are supplanted by fibers of white fibrous tissue, a tough, strong, unyielding material that serves everywhere throughout the body as a binding element, and of which tendons, ligaments, and scars are largely formed. Together with this fibrous change in the walls of the arteries a thickening of the walls occurs which, actually narrowing the caliber of the vessel, encroaches upon the space for blood. An artery that has undergone fibrous change and thickening is deprived of much of its elasticity, a quality that we have seen to be indispensable to proper functioning. In addition, more or less calcium, the presence

of which in bone is responsible for its hardness, may be deposited in the already thickened walls of the arteries. The end-result of all these changes that may take place in the walls of the larger arteries is serious injury to the flexible, elastic artery, which, in health, accommodates itself so easily to varying pressures during each cardiac cycle, which tends to lessen the height of the systolic pressure, and which changes the vigorous spurt of the blood as it is received from the heart to a steady onflow as it is delivered to the arterioles and capillaries;—the artery of normal type is converted into one with stiff, unyielding walls, which cannot receive elastically the vigorous thrust of blood at each heart beat nor modify the pulse wave into a steady onflow. Such a diseased vessel has much in common with a rigid metallic tube. In the larger artery thus damaged the maximal pressure may remain much the same as the pressure exerted within the chamber of the heart, since none of the energy is absorbed and rendered temporarily latent through the mediation of an elastic vessel wall; and since the normal elastic recoil of the wall of the healthy large artery behind the pulse wave with its continuing squeeze

upon the contained blood is absent, the minimal pressure will, other things being equal, tend to fall below the average normal figure. The difference between maximal and minimal blood pressure is called, as we have seen, the "pulse pressure," and it will be recalled that it is a measure not only of a large part of the work which the heart is called upon to accomplish with every beat, but also of the strain to which the vessel walls are subjected with the passage of each pulse wave.

In arteriosclerosis of the larger arteries, therefore, the maximal (systolic) blood pressure will tend to be raised, the minimal (diastolic) pressure to be lowered, and the pulse pressure to be increased. Normal arteries, in which the elastic quality is unimpaired, can easily withstand, at least for short periods of time, a marked increase of pulse pressure; but with a gradual increase of the rigidity of the arterial walls there develops an increasing inability to expand elastically to the passing pulse wave, until at last, under the continued hammering of the systolic pressure, the walls begin to "give way." Then ensues either a dilatation of the vessel, seen oftenest (by X-ray) in the aorta just

after it leaves the heart, or an actual lengthening, with tortuosity, plainly to be seen by the eye in the arteries of the temple. The actual hardening of the walls of the arteries of medium size can be appreciated by the finger in various parts of the body.

Not always do the arteriosclerotic changes progress to this point, however, nor do they occur equally distributed throughout the various arteries of the body. The arteries supplying the limbs and the head may, in some cases, be predominantly affected while the smaller arteries and arterioles hidden in the internal organs may escape; and, in other cases, the arteries of the vital organs may be badly sclerosed without any evidence of the process appearing in vessels accessible to sight or touch. Moreover, arteriosclerosis may affect the arteries of one region while it spares those of another. Thus evidences may be present of arteriosclerosis of the vessels of the brain alone, or of the kidneys alone, or of those small vessels that nourish the muscle-tissue of the heart wall, or of the peripheral vessels only. It is certainly quite common, however, to find the arteriosclerotic process very widespread.

The change from normal to sclerosed blood vessels is, of course, gradual, and the beginning of the change is insidious, and without symptoms. And in this insidious beginning and gradual development lies the great danger to the possessor of the vessels. As a rule he is not aware of the process until it has become well established and until symptoms have begun to make their appearance. Moreover, the symptoms vary with the variable location of the process in its greatest intensity. Since in this volume we are most concerned with blood pressure, it may be pointed out that sclerosis of the smaller arteries and arterioles has a greater effect upon that pressure than has hardening of the larger arteries. The reason for this will be clear, when the compensatory effects of the tone of the smaller vessels are remembered. Thus, with a tendency to higher pressure through stiffening of the walls of the larger arteries, a compensatory dilatation of the arteriolar system may be sufficient to hold the resultant blood pressure down to its usual levels. When the site of the sclerotic process is in the smaller arterioles themselves, however, there is impairment of such compensatory function.

Since sclerosis of the smaller vessels results almost uniformly in narrowing of their caliber, the effect upon the minimal pressure is the same as that of heightened vascular tone from muscular contraction of the vessel walls, except that it is permanent and due, not to normal physiological adjustments, but to abnormal structural changes. Abnormal resistance to the outflow of the blood from the system of larger arteries is thus created (increased minimal blood pressure), which the heart must overcome by more forceful beating (causing increased maximal blood pressure). The maximal pressure rises proportionately higher than the minimal, as is the rule, so that the pulse pressure is increased. A greater pulse pressure means a greater strain upon the already damaged vessel walls, with stretching and the formation of still more dense tissue. This, in turn, leads to still further narrowing of the caliber of the vessels, completing a vicious circle. When we see a high diastolic pressure without a pulse pressure that is higher than normal, we suspect some weakness of the muscle of the heart that prevents the maintenance of the systolic pressure at a high level.

Thus far, in speaking of arteriosclerosis, changes in the circulatory system only have been considered. It is to be recalled, however, that the function of the circulatory system is to furnish blood to all the organs of the body and to drain these organs of blood; not only do blood vessels (arteries) carry food and oxygen to the organs, but blood vessels (veins) also take away from them the waste products that result from their activities. The health of each individual organ, as well as the health of the body as a whole, is dependent upon an adequate supply of blood. If, then, the supply of blood to an organ is impeded by narrowed arteries, or if, through loss of the normal pliability of the vessel walls, the supply can not be gauged to the changing needs of that organ, then its functions must suffer. Eventually the very structure of the organ will be affected by reason of faulty nutrition; for an interesting fact regarding the living human body is that wherever an organ, a gland, or a cell functions less, it grows smaller. Thus the unused muscles of the East India holy men become reduced to little more than mere strands of fibrous tissue;

the unused eye of a "cross-eyed" person loses the function of vision.

Now sclerosis of the small blood vessels (arterioles) within the vital organs leads to more or less marked structural changes in those organs, changes that involve the ability of the organs properly to function. If this occurs in the kidneys, there is a slow impairment of kidney function; if in the brain, mental changes may become manifest, or a paralytic stroke may occur; if in the wall of the heart itself, attacks of angina pectoris or of other heart disorders may be experienced; and so on.

Of the causes of arteriosclerosis much has been written and but little is actually known. Certain it is that heredity must play a large part here, as it apparently does in the origin of so-called essential hypertension (hyperpiesis; hypertension without demonstrable organic changes). Indeed it is probable that hereditary disposition is the predominant factor. It is not at all unusual to find a history of attacks of apoplexy running through a family; if it be objected that the "stroke" was a complication of kidney disease (and thus presumably not directly due to vascular disease in the brain), it can often

be shown that the kidney disease was caused by sclerosis of the arterioles of that organ, that hypertension was associated with the kidney disease, and that, finally, a vessel in the brain, sclerosed just as were those in the kidney, gave way to the increased blood pressure. Still other evidences of familial arteriosclerosis might be adduced.

The acute infections of youth may be responsible for the development of more cases of arterial hardening in after life than we have been accustomed to believe. Recurring tonsillitis and other infections due to streptococci may be of importance. Thayer has called attention especially to the possible relation of typhoid fever in the earlier years of life to subsequent changes in the walls of the arteries. Indeed, when it is remembered how often the toxic substances elaborated in the course of scarlet fever attack the kidneys and leave them impaired, and how frequently the diphtheria toxin causes (or, rather, did cause, before the blessed advent of antitoxin) severe paralyses due to injury of the nerve fibers, it is not hard to believe that other structures in the body, especially the blood vessels, may be harmed by these and similar poisons, and that the

vessel walls, exposed as they are constantly to the severe stresses of the circulatory cycle, sooner or later show degenerative changes.

The poisons retained in the system and circulating in the blood as a result of impaired function of the kidneys are a potent source of damage to the arterial walls. Even though frank arteriosclerosis may not result at once from the poisoning, it is believed that these poisons carried through the blood may affect the vasomotor center in the brain and give rise to an increased blood pressure through resulting constriction of the walls of the arterioles.

Besides the deleterious effects of the poisons produced in the course of the acute infectious diseases and of the poisons that are retained in the system when there is faulty elimination by the kidneys, certain poisons absorbed from the outer world may exert a damaging influence upon the arterial walls and lead subsequently to their thickening. Workers in lead and in mercury, especially, suffer such damage, a fact of the greatest importance for personal hygiene and for the hygiene of industries.

In advancing age retrograde changes of various

sorts occur throughout the body. The arteries do not escape, and we find arteriosclerosis occurring in ever greater degree as the years of a person increase. In the absence of the poisonings above referred to, the age at which thickened vessels become noticeable and the rapidity with which the process of arteriosclerosis advances in a given person are, in a way, a measure of that person's inherited disposition in this one particular. Arteriosclerosis though very rare in infants is not wholly unknown in them; on the other hand, we see some persons in even advanced old age who show but few or no signs of it. The old saying that "a man is as old as his arteries" has some truth in it as far as it bears upon the "expectation of life"; but there are such great individual differences to be met with in arterial conditions that any attempt to guess, on information derived from them, of the actual number of years a person has lived, would be little less than foolhardy.

Certain metabolic diseases, notably diabetes mellitus and gout, also predispose to arteriosclerosis and may be accompanied by high blood pressures. In these diseases an excess of certain

substances (sugar in diabetes; uric acid in gout) can constantly be demonstrated in the blood. Tuberculosis is sometimes a cause of arteriosclerosis of the larger vessels, but it is rare to find tuberculosis associated with high blood pressures; in most cases of this malady abnormally low blood pressures are encountered. An infection with syphilis is held by certain writers to predispose the patient to the development of arteriosclerosis.

Caffeine, nicotine, and alcohol have been accused as potent causes of arteriosclerosis, but recent researches do not seem to support the accusation so far as moderate use is concerned.

Excessive mental or physical work, and indeed excesses of all kinds, do seem to have a real causal effect in the production of disease of the arteries. Particularly is this true of over-eating. The heavy eater may also be physically inactive; gluttons are notoriously negligent of proper bodily exercise. Obesity after middle life is very often associated with high blood pressure and some arteriosclerosis. Stuffing of the stomach puts a great load on the digestive system, and this in turn interferes with normal circulation and respiration precisely at a

time when the digestive system is demanding an increased supply of blood for its complicated work. As we have seen, the blood pressure is normally always higher just after a heavy meal. If the strain on the circulatory system caused by digestion be increased by overloading the stomach, and especially if the strain be habitually repeated, there will almost surely come a time when damage will be done to the arteries and "hardening" will gradually ensue. Moreover, very often the heavy eater is simultaneously an immoderate drinker of alcohol, an inordinate smoker of tobacco and perhaps inclined to excesses in still other directions. He who wishes to live so as to protect his arteries from damage, will avoid over-abstemiousness on the one hand and over-indulgence on the other; "safety lies in a middle course."

The possible causes of arteriosclerosis are, as we have seen, many; and some of them are coarse, others subtle and their mode of action obscure. In all fairness, it must be added that sometimes on studying a person manifesting arteriosclerosis, no definite cause can be found, and it is necessary to conclude that the person has been unfortunate in

the original quality of his "tubing"; that is to say, that through his inheritance he has come to be the possessor of arteries of an inferior grade.

We have thus far in this chapter discussed the forms of hypertension that lie at the two ends of a series; we have spoken (1) of those forms of hypertension that *are not* associated with any demonstrable organic change in the body, and (2) of those forms that *are* definitely associated with such changes. But in so complex an organism as the human body, abnormal function of any kind seldom exists long without becoming associated with at least some corollary organic effects. We cannot expect, for instance, to find many cases of simple hypertension, especially if it persist for any length of time, without being able to discover sooner or later that it has become associated with organic changes here or there in the body. The members of this end of the series of hypertension cases merge insensibly into the members of the other end of the series through the members in a great middle area; the progression is naturally from the simple hypertensions to those associated with organic changes. Indeed, by some authors simple or essen-

tial hypertension, or hyperpiesis (to give it all the names we have mentioned in this chapter) is considered but the preliminary stage of a malady that will later further reveal itself in arteriosclerotic processes in the large peripheral arteries and in the arterioles of the vital organs. To these writers the sequence is clear from simple excessive blood pressure to arteriosclerosis and so to all the maladies of kidney, brain, and heart that mark the end of so many elderly persons' lives. There are other writers who believe that the first change is a subtle degeneration of the walls of the smaller arteries and arterioles, with a consequent rise of blood pressure, and that after this a vicious circle is established, the rise in blood pressure leading to further degeneration of the arteries.

Whatever the sequence, permanent increase of blood pressure and degeneration of the arterial and arteriolar walls seem to be complementary processes; together they lead gradually to the impairment of various vital functions. A brief survey of the functions that are thus impaired, with great danger to the health and even to the life of the individual, must be reserved for another chapter.

CHAPTER VII

THE HEART, THE KIDNEYS, AND THE BRAIN IN PATIENTS MANIFESTING HIGH BLOOD PRESSURE

Both the functional and the organic types of hypertension become associated, sooner or later, with structural alterations in various organs of the body—insidious changes, which impair the health and which will eventually, if unchecked, terminate life. Some of these changes have been hinted at in previous chapters, but it will be well now to look a little more closely at the more important of them. In considering the concomitants of high blood pressure, we shall pay attention particularly to the changes that may occur in the heart, the kidneys, and the brain, for these are vital organs that must function perfectly if health is to be conserved. Moreover, these are the organs that suffer oftenest in persons who manifest high blood pressure and (when long continued) its corollary,

arteriosclerosis, with its attendant disturbances to the circulation. In the previous chapter we have seen how some of these changes may be brought about; now we must inquire into the special influence of these changes upon the three organs spoken of, and at the same time we shall try to discern how the chains of morbid phenomena are forged.

Though the story is not a pleasant one, it must be told if we are to arrive at an understanding of the mechanisms by which patients manifesting hypertension come to have their lives endangered. But the reader who chances to have a high blood pressure must be warned emphatically against the tendency to search within himself for all the complications of hypertensive troubles of which he now learns. The discovery and management of such complications is the task of the physician, not of the patient. For that very reason, no detailed list of symptoms referable to these complications is here written down. Too many non-medical readers might become introspective and develop unnecessarily states of anxiety from worrying about themselves and their future. It has already been

shown how baleful the effects of such mental states may be upon even "normal" blood pressures and it will, accordingly, be easy to understand why the hypertensive patient should be carefully shielded from all unnecessary worry. It can never be the purpose of any good physician to arouse fear in his patients. It is, rather, his duty to point out carefully to the patient, without unduly alarming him, the pitfalls that may lie before him and to teach him how to avoid them. Indeed, the purpose of this little book is to perform for its readers that very service in respect of arterial hypertension. Though the possible complications of that hypertension, as we have said, are not pleasant to dwell upon, they must be set forth in this chapter in order that the reader may better understand the necessity for his observance throughout life of those principles of good personal hygiene (inclusive of proper diet) which the science of preventive medicine has shown are most effective in postponing the advent and progress of the processes that underlie hypertension. In this spirit of sensible caution, then, and without fear, let us examine some of the possible complications of hypertension, particu-

larly those that concern the heart, the kidneys, and the brain.

If we take the simplest case, that of so-called "functional" or "essential" hypertension (or hyperpiesis) the exact cause of which, it will be recalled, is not yet fully known, it will be evident that increased blood pressure within the arteries means that extra work is required of the heart, since the maintenance of a satisfactory circulation when there is increased resistance to the outflow of blood from the heart at each beat will depend upon more forcible contractions of the walls of the heart. The muscle of the heart wall, like all other muscle tissue in the body, responds to increased work with an increase in size of the individual muscle fibers, and with a consequent increase of the whole muscle mass. No one should be surprised, therefore, to be told that some enlargement of the heart occurs in chronic arterial hypertension. This enlargement may be demonstrable within four weeks after the appearance of a permanently raised blood pressure; with time the enlargement may progress, in the course of years or decades, to an almost unbelievable extent. Some of the largest hearts en-

countered in postmortem examinations by pathologists are thus explained. But when the heart is called upon to perform over a long period an amount of work that is greater than that called for under normal conditions, changes other than that of mere hypertrophy (increase in size and strength) gradually occur. Eventually, say after several, often only after many years, the nutrition of the heart will begin to suffer; degeneration of the heart muscle fibers may set in, fibrosis of the walls of the heart may develop, and the musculature of the heart will become unequal to its task. When the heart muscle thus begins to flag, the chambers of the heart will begin to dilate, the maximum systolic blood pressure, which is largely dependent upon the heart's action, will fall, though it may still remain well above the average level maintained in health. And since the minimum diastolic pressure is still maintained at an abnormally high level, owing to the contraction of the walls of the peripheral arterioles (the fundamental condition in essential hypertension), the fall of the maximum systolic blood pressure involves a fall in the pulse pressure, and this means, in turn, that

the circulation of the blood in the body becomes insufficient. Then follow the signs and symptoms of "heart failure," a term that means, not the failure of the heart to beat at all, but its failure to beat powerfully enough to maintain an efficient circulation of the blood.

It should be remembered, then, that essential hypertension may, sooner or later, lead to an inability of the heart to maintain a proper circulation of blood, one of the earliest symptoms of which is undue breathlessness upon exertion. Sometimes the sequence of events is rapid, but more often the changes develop very slowly over a long period of years; and it is comforting to know that when the progress is slow, much may be done by the family physician to delay it.

Whether we accept the view that functional hypertension is caused by an increased tonus of the arterioles due to the circulation in the blood of some unknown poisonous substance, or the view that it is the result of unrecognizable arteriosclerosis hidden in some of the finer organ arterioles, it is in either case true that so-called functional hypertension that continues for a long time eventu-

ally becomes associated with a frank arteriosclerosis. Essential hypertension has indeed been spoken of by some writers as the "pre-sclerotic" type of hypertension. The walls of the blood vessels, exposed to the increased pressure of their contained blood, sooner or later suffer damage; they gradually undergo fibrous thickening with consequent diminution of elasticity. At the same time, each beat of the enlarged heart throws its quota of blood into the damaged vessels with greater violence in order to overcome the greater resistance offered by the increased blood pressure. The larger vessels, unable longer to yield elastically to the inrush of blood at each heart beat, must yield by a gradual enlargement; hence, dilatation of the aorta and of the larger vessels ensues. Eventually, the degenerative changes already noted in the heart muscle itself lead to alterations in the heart wall that are somewhat of the nature of those that occur in the arteries in arteriosclerosis. Upon this damaged and over-laboring heart a still greater burden is ever being placed, for sclerosis of the vessel walls, particularly those of the smaller arteries and arterioles, raises the minimum diastolic blood

pressure gradually ever more, as we have seen. A vicious circle is involved; we need scarcely distress ourselves with too vivid contemplation of the inevitable final result to the patient.

When arteriosclerosis develops in those two small vessels which leave the aorta just at its junction with the heart and run downward in the heart muscle itself (the coronary arteries), the nourishment of the musculature of the heart is especially interfered with and the stage is set for the appearance of the atrocious pain that is known as "angina pectoris." It is mentioned, here, merely to place it among the more serious complications of hypertension and arteriosclerosis. It may be remarked, however, in passing, that some of the most serious cases of angina pectoris are due to a sclerosis of the coronary arteries that occurs without the general changes that give rise to high blood pressure; in such cases the blood pressure, instead of being higher, may be much lower than normal.

When we turn to the complications in which the function and structure of the kidneys become involved we are again confronted with the problem of wherein lies the first deviation from the normal.

It may be that the first step in the process of kidney involvement is a constriction of the renal (kidney) arterioles and capillaries due to some unknown cause (possibly a cause similar to that of essential hypertension), resulting in a narrowing of their lumen and consequently in a diminished supply of blood to the glandular structures of the kidney which are charged with the function of secreting urine; poisonous products that should be excreted in the urine would then be retained in the circulation, and be responsible for a rise of blood pressure, either through direct stimulation of the arteriolar walls or through stimulation of the vaso-constrictor center in the brain; and this increased blood pressure could, in its turn, lead to the appearance of arteriosclerosis, which could still further damage the tiny blood vessels in the kidney (as well as in other organs) and so lead to a further diminution of renal function. Or, it may be, as some think, that the arteriosclerotic process is prone to develop early in the kidney and is the first change in the series, causing impairment of renal function; the ensuing retention of poisonous products could lead to spasm of the

arterioles throughout the body, a pathological physiological response answering the need of a rise in the blood pressure to force more blood through the damaged renal vessels. The truth, we are inclined to believe, is probably to be sought still farther back in a chain of events than at the links suggested by either of the views mentioned; it would not surprise us, if some day it should be determined that hypertension is not the primary cause of arteriosclerosis, and that arteriosclerosis is not the primary cause of hypertension, but that rather both hypertension and arteriosclerosis are due to the presence of some poison, of as yet unknown nature and origin, circulating in the blood. Such a hypothetical poison may turn out to be the original cause of the whole complex syndrome, in which event its nature and source and the reason for its non-elimination will have to be investigated. In the present state of our knowledge it is, perhaps, better not to try to arrange kidney lesion, hypertension, and arteriosclerosis in any specific order of sequence of occurrence, but to recognize that when they co-exist ("cardiovascular-renal disease"), there is a possibility that all three may

be due, directly or indirectly, to some common, though still unknown, cause.

Certain it is that changes in the walls of the renal arterioles often develop at an early period of the hypertensive malady. The nutrition of the secreting elements of the kidney then suffers, with consequent impairment of renal function. With the insidious advance of the process, there is actual death from starvation gradually of one after another of thousands of secreting elements. In time the proportion of atrophied elements may become so great that the kidneys shrink in size, and though parts of the kidneys still work very well, there is such a marked reduction of the filtering and secreting elements that the kidneys are unequal to their normal tasks; renal insufficiency becomes recognizable through certain tests that the physician can make. Retention in the body of poisonous products that should be excreted becomes ever more pronounced and associated with such retention there is an increased rise of blood pressure. In some instances, the blood pressure may reach very high levels; in fact, the highest permanent blood pressures known are those that are met with in

this type of kidney disease, which is commonly called, especially in non-medical circles, "chronic Bright's disease." When the condition has become well established, it is not uncommon to find as permanent levels a maximum systolic blood pressure of 200 millimeters of mercury, or more, and a minimum diastolic pressure of 100 to 130 millimeters; instances are on record of maximal pressures exceeding even 300 millimeters of mercury! Along with the long-continued rise of blood pressure both arteriosclerosis and hypertrophy of the heart develop, in the manner already described. The terminal event in the patient may depend upon failure of either the heart or the kidneys to function sufficiently to permit of the continuance of life. If the heart fail, the circulation becomes so poor that fluid collects in the cavities of the body and in the loose tissues under the skin ("dropsy"); if the kidneys fail, the poisons retained may cause delirium, convulsions and unconsciousness ("uræmic poisoning").

It remains, in connection with chronic arterial hypertension, to speak of the brain, the third of the three organs (heart, kidneys, brain) that to-

gether have been called the "tripod of life." Though hypertension alone or in association with faulty elimination by the kidneys, may give rise to brain symptoms such as headaches, sensations of pressure in the head, and dizzy spells, much more serious phenomena, as we shall see, may follow upon the occurrence of sclerosis of the small arteries of the brain.

In any sclerotic vessels, the thickened walls mechanically reduce the caliber of the vessel and this reduction of the internal diameter of an artery alters both the amount of the blood flow through it and the speed of the flow. These changes in the blood flow, together with the lessened power of adjusting the blood supply to the brain to changing needs of that organ for blood, have much to do with the slight mental symptoms that everyone recognizes as characteristic of advancing age. With increasing years, especially beyond the fifth and sixth decades, men's minds become, as a rule, less flexible; in later life, men sometimes find difficulty in mental grasp, especially when the topics dealt with are complicated; and they are often forgetful and sometimes irritable. They tend to waken early

in the morning, and during the day they tire easily on either physical or mental exertion. There is a gradual narrowing of interests, a loss of power to do productive work, and a disinclination to new undertakings. No one is surprised to observe such symptoms in elderly persons, and physicians attribute them to the low grade of arteriosclerosis that normally accompanies advancing age. This "physiological arteriosclerosis" may not be associated with arterial hypertension.

Slow cerebration, however, is only one result of the altered blood flow in the arterioles of the brain, for wherever blood loiters on its journey, in the brain or elsewhere, especially where there is some diseased condition of the vessel walls causing narrowing and roughening of the inner surface, there clotting is apt to occur. The formation of such a clot in various small arteries and arterioles is not a particularly rare occurrence in arteriosclerosis; it may occur in regions of the body in which it does not proclaim its presence by any marked symptoms. But in the delicate organ we are considering every little arterial branch nourishes some important bit of brain tissue, which

may have a special function not shared by any other portion. Interference with the nutrition of that bit of tissue, even though it be slight and temporary, may reveal itself by a disturbance of sensation, of consciousness, of motion, of speech, or of memory. Narrowed vessels may undergo spasm at times and temporarily cut off the blood supply. In this way arise the transient numbnesses and paralyses of arteriosclerotic and of hypertensive-arteriosclerotic patients. Or an artery may become completely stopped up, either by projections of the altered wall into the vessel, or by a clot of blood. The plugged vessel in the brain may be very small and in a so-called "silent area" of the brain, injury to which can scarcely be recognized; or the artery may supply one of the "non-silent areas," where the least interference with nutrition, disturbing function, causes prompt and more or less prominent symptoms. Thus, as the result of obstruction to the flow of blood through a small artery in the brain, a numbness or a paralysis in one or more of the limbs may quietly appear, or one eyelid may droop helplessly over the eyeball; or the power of speech may be lost or

greatly disturbed; or there may be a shocking loss of memory; or the person may even become unconscious.

This obstruction of blood flow due to clotting within arterioles and small arteries is called *thrombosis*, and since the smaller or larger areas of the brain that are thus deprived of blood actually die and undergo disintegration and absorption the condition is sometimes spoken of as "softening of the brain." In patients with severe disease of the arteries of the brain, one artery after another may become occluded, causing a series of "softenings," with corresponding successive losses of brain functions.

In thrombosis, no blood escapes from the vessels that are plugged; but the brain is subject to another sort of arteriosclerotic vascular accident that is correctly described by the laity as the "bursting of a blood vessel" in the brain, and which physicians refer to as "cerebral hemorrhage" or "apoplexy." This rarely occurs except when advanced arteriosclerosis of the brain vessels and marked arterial hypertension accompany one another, the simplest explanation being that the diseased vessel-wall rup-

tures under the heightened pressure of the blood. The explanation is upheld by the relative frequency of apoplexy in elderly persons immediately after the influence of something that we know temporarily raises the blood pressure, for example, violent muscular exertion (such as running for a train, or suddenly lifting a heavy weight), sudden chilling of the skin by a cold bath, coughing or sneezing after a big meal, alcoholic excess, or strong emotional excitement (anger; fright; coitus). Still, it must be acknowledged that some are "stricken" while lying quietly in bed; it is not so very uncommon for a patient to be found after a night in bed showing signs that indicate that a blood vessel has ruptured during the night.

These patients may recover some of the functions that are at first lost, but when the paralysis that occurs is extensive, it is common to see them remain permanently paralyzed in one or more parts of the body. The reason for partial recovery lies in the fact that the brain does not necessarily "soften" as in thrombosis. The blood that escapes from the broken vessel immediately into the brain substance does harm partly through its presence as

a foreign body and partly by the pressure that it exerts in the brain tissue. If the blood pressure be high, a hemorrhage from even a small artery can exert considerable pressure upon the soft substance of the brain. But often the blood is gradually absorbed and the pressure is relieved. Some of the symptoms pass off, those that remain depending upon the amount of permanent injury done to the brain substance.

Not only is arterial hypertension thus an indirect cause of cerebral thrombosis and hemorrhage, but in the case of hemorrhage the reverse is also true. The brain tissue is soft and yielding, but it is enclosed in a hard, bony, unyielding box—the skull. When hemorrhage occurs within the brain, it squeezes the brain substance against its enclosing walls and tends to flatten it against them. If the pressure process be vigorous enough some of the vital centers of the lower parts of the brain may be pressed upon and (at first) stimulated. Among these is the vasoconstrictor center, which, as we have seen, when stimulated increases the tone of the arteriolar system and hence raises the blood pressure; this in turn may increase the bleeding,

with the production of an ever increasing pressure within the brain, until anemia of the brain results, and it, with its vital centers, ceases to function.

Apoplexy, serious as it is, does not occur as frequently as many people imagine. It is comforting to know that of every 100 persons with maximal systolic blood pressure of 170 millimeters of mercury or over, statistics show that about 85 may look forward to continued freedom from apoplexy.

CHAPTER VIII

LOW BLOOD PRESSURE ("ARTERIAL HYPOTENSION")

ALTHOUGH this little book on blood pressure concerns itself chiefly with that aspect of the subject that chiefly interests its readers, namely, blood pressure above the normal range, it would seem worth while to note, for the sake of completeness, that blood pressures that range below the normal do occur and are sometimes of importance.

This condition of low blood pressure, spoken of as "arterial hypotension," may accompany acute illnesses, such as measles, scarlet fever, diphtheria, acute rheumatic fever or typhoid fever; in pneumonia, it may or may not be observed. It appears also in the wasting diseases (such as tuberculosis and cancer) and in the anemias. It is also often observable after a severe hemorrhage, a profuse diarrhea, or a prolonged vomiting—all events that involve the loss of considerable fluid from the

body. It occurs, too, as a symptom of surgical shock, that condition of profound collapse, sometimes fatal, that may follow upon certain operations or severe injuries. In all of the instances mentioned the arterial hypotension is distinctly secondary to a definite provocative cause and the blood pressure returns to its normal range after the underlying cause has been removed.

There is another type, however, which, although not of great significance as far as the health or the expectation of life of the possessor is concerned, is still of considerable interest. It is met with oftenest in persons of the so-called "asthenic habitus"; that is to say in persons who are tall and slender, have long necks and long narrow flat chests, round shoulders, long extremities and feeble muscles. These individuals being usually thin and rather pale, give the impression of not being robust. They tire easily; their hands and feet are frequently cold and bluish and their palms moist; they complain often of "indigestion," of constipation and sometimes of headaches and of vague pains. They may suffer from mild mental depression, or from nervous symptoms of various sorts.

The range of the maximum systolic blood pressure in these persons is from 90 to 115 millimeters of mercury and that of the minimum diastolic pressure from 60 to 80 millimeters. This "essential" hypotension would seem to be related in some peculiar way to the particular physical make-up above described; the abnormally low blood pressure must be assumed to accord with that "make-up" just as "normal" blood pressure is in accord with the "make-up" of an average individual. It is probable that in persons of asthenic habitus, the balance of the internal secretions and of the impulses in the vegetative nervous system is somehow different from what exists in average human beings. In support of this view it may be mentioned that in Addison's disease, in which there is disease of one of the organs of internal secretion, namely the suprarenal capsules, very low blood pressures have been observed.

The subject of physical types is rightly receiving ever more attention from the modern doctor and much is being written in the medical books and journals about it. Just as abnormally low blood pressures are commonest in persons of asthenic

habitus, so abnormally high blood pressures occur most frequently in persons of the opposite type of build, namely in those with short necks, broad thick chests and a tendency to obesity. Indeed, physicians often refer to this type as the "habitus apoplecticus," making use of a term that refers to the liability to cerebral apoplexy of those to whom it is applied. Perhaps when the layman, as well as the physician, begins to realize that persons differ from each other, not alone in their physical appearance, but also in their physiological and mental reactions, and that they behave differently in disease and when acted upon by drugs, the happy day will begin to dawn when neighbors will cease to diagnose their ills over the back fence and the "patent medicine," advertised as good for nearly everything and "certainly for everybody regardless," will become a historical curiosity, relegated to the limbo in which already Bishop Berkeley's tar water and Perkins' magnetic tractors are confined and whither the anti-rheumatic horse-chestnut on a string is finding its way.

No better example of the necessity of the consideration of the whole person (body and mind)

when studying any abnormal process could, perhaps, be chosen than this condition of arterial hypotension. On its face, abnormally low blood pressure would seem to indicate a departure from health; but when considered in the light of the individual make-up it takes its proper place as a part of a characteristic human type. That type, as a whole, is not a perfectly normal type; but the low blood pressure that occurs in it is in accord with the other constituents of the type. Much can be done to improve the physical condition and the physiological states in persons of the type mentioned, and with the general improvement the blood pressure will often be maintained at a higher level. The measures that have been found most useful include the avoidance of bodily and of mental fatigue, the insistence upon a sufficient amount of sleep at regular hours, the overcoming of constipation, and the rigorous practice of moderate daily setting-up exercises under the watchful eye of a physician. Patients with low blood pressure should of course undergo a thorough physical examination at the hands of a competent physician before taking up the routine outlined; the dangers of self-

treatment of either hypotension or hypertension cannot be too strongly emphasized. Just think, for example, how disastrous it might be for a patient to undertake of his own accord to treat his low blood pressure by active exercise if his hypotension were due to tuberculosis of his suprarenal capsules!

CHAPTER IX

WHAT TO DO?

It is pleasant now to be able to turn from the somewhat depressing recital of the causes, the accompanying conditions, and the consequences of chronic arterial hypertension to the more hopeful theme of its prevention and amelioration. Much may be done to ward off the appearance of the process; even after it has appeared and been recognized, its further advance is often preventable. None of us can hope to avoid some degree of hypertension and even of moderate arteriosclerosis as we grow older, for they are parts of the aging process; but we can live our lives, if we will, in such a way as to discourage any abnormal rise of blood pressure in our later years. If we are wise we shall take a leaf from the book of the juggler, the dancer, and the acrobat; like them, we shall not only begin our training early, but also endeavor to keep it up without a break.

To begin at the beginning of the hygienic regime that will keep the blood pressure within its proper bounds, we must remember that those are fortunate whose blood vessels and general physical make-up at birth and during development are of standard quality. No one has ever put the case better than Oliver Wendell Holmes when he said that if we would be healthy we must choose our grandparents wisely. Heredity is recognized to-day as a large factor in the determination of the cause of blood pressure. But since our own inheritance is a factor beyond our control we must cheerfully accept the characters transmitted to us as we find them. When we remember, however, that we shall probably be grandparents in our turn, we shall consider it a duty, to those who shall come after us, when we contemplate parenthood, to consider carefully the prospects of those new beings that may result from the fusion of our germ cells with those of our mates. It is to be feared, however, that such eugenic considerations play as yet but a subordinate rôle in the choice of marital partners or in decisions as to the advisability of parenthood. There may be a few in each generation who are wise

enough and strong enough to guide instinct by reason; for the majority, instinct is likely to defy efforts at rational restraint. When it comes to making the most of our own lives, however, many of us will listen to good advice and some of us will act upon it. In early life, when acute infections most often attack us, the utmost care must be taken to insure complete recovery and to be patient during convalescence, if our blood vessels are to be protected from injuries that may dispose them to arteriosclerosis later. We do not know exactly how much vascular damage is done by measles, typhoid fever, scarlet fever, and other infectious diseases, but we do know that the vessels do not escape scot-free from the effects of the poisons produced by the bacteria of disease, any more than does the rest of the body. The man, or child, who rises from a sick bed prematurely and plunges immediately into his usual more or less strenuous life can surely be accused of neglect of his future health. The bacteria that cause bad colds, sore throats, and tonsillitis are capable of doing great harm to the heart, to the blood vessels and to the kidneys; much misery would be avoided if common

colds and sore throats could be prevented, or if persons suffering from them would submit themselves promptly to a wise physician's care.

To say that good habits of personal hygiene, such as adequate sleep, plain food in moderate quantity, proper exercise, fresh air, frequent bathing, self-control and avoidance of all excesses, should be impressed upon the growing child is to utter a platitude; but we dare not fail to utter it, for far too often it is assumed that youth, with its buoyancy and elasticity, is proof against infractions of hygienic laws. Physicians now believe that many of the diseases of middle age, including the group of hypertensive disorders, can be followed back to an origin in long-established habits of faulty hygiene.

As the child approaches maturity when his productive life begins, with all that this implies of increasing responsibilities and entry into the bewildering complications of modern social and business life, it becomes even more important for him to "watch his step" and to remember that a healthy old age is not solely a gift of the gods, but rather a prize valiantly to be striven for.

The average young man of to-day does not envy Thoreau his lonely hut by Walden's shore, nor the peaceful life of the beloved entomologist of Provence; he desires, and rightly, the strenuous life of the age in office and in workshop. But if he be wise he will avoid complete submergence of himself in his work. He will cherish the ability to throw off his business cares and worries when he leaves his work for the day; for after a day of strenuous activity, it would be silly not to relax the tension to which his whole organism has been keyed up. Furthermore, he will put the correct valuation upon recreation. In his choice of hobbies —and every man should have at least one or two of these—he will see to it that they are as different as possible from his main occupation. He will also recognize that his social recreations should actually diminish tension and he will not permit himself to be drawn frequently into situations in which hectic excitement and dissipation lay further levies upon his nervous system. Of equal, if not of even greater, importance to him will be the ability to drop his work entirely at frequent intervals for a day or two at a time. The demand of the

Mosaic law that one day in seven be given to rest is only one of the proofs that this old code gave consideration to hygiene as well as to religion. Owing to the greater complexity of life, the need of periods of relaxation is far more imperative nowadays than it was in ancient times. Not only should week-ends and an afternoon each week be given to "play" of some kind, but an annual or semi-annual vacation should be taken regularly, no matter how absorbing or how exacting business or professional responsibilities may seem to be. Among the persons in this country who carry the heaviest responsibilities and who are animated by the highest sense of duty, there is a growing tendency to arrange for a long vacation in the summer, for a shorter vacation in midwinter and for briefer vacations at Thanksgiving and Easter. And the wisest of these persons take their longer vacations in quiet places, in the woods or on the water far away from the din, the bustle and the artificiality of town and city life.

Remembering the relationship of arteriosclerosis to high blood pressure, and that the measures advised for the prevention of the former apply also

to the prevention of the other, it is interesting to recall what the late Sir William Osler once said about the "wear and tear" of life.[1] "The conditions of modern life," he wrote, "favor arteriosclerosis, as a man is apt to work his body machine at high pressure, and often takes less care of it than of his motor. The best express engine from the Baldwin works, run day by day at maximum speed, will not last one-tenth of the time it would do if it were not so pushed. But nowadays, with the human engine it is top-speed or nothing, and we cannot wonder that it early shows signs of hard usage. In the fourth or fifth decade, even with the best of habits in eating and drinking, the incessant strain and anxiety of public life or of business may lead to degeneration of the blood vessels. Mental exertion is not of itself injurious, and the life of the student need not be one of great tension, but the mental exertion of the modern business man is of a different kind. Competition is so keen and the environment so stimulating that, even without social or political am-

[1] Osler, W. *Modern Medicine*, Philadelphia, Lea & Febiger, 1908.

bitions, high pressure seems a necessity. The tragedies of life are largely arterial. Represented in the old mythology as winged, Nemesis, the goddess of the Inevitable, may still be pictured with a wheel, the wheel of life, to the ceaseless revolutions of which the circulation ministers. How often does her fatal touch call away in their prime the best and the bravest—whose only fault has been the unselfish abuse of the body machine!"

After adequate attention to work, rest, recreation and mental tranquillity, the most important measure preventive of high blood pressure is a suitable diet. The quantity of food eaten is far more important than the quality, though both should be considered. Even an ordinary sensible meal causes a temporary rise of blood pressure, which is a normal reaction and not injurious; but when a meal is so large as to overdistend the stomach, to drag upon the abdominal blood vessels, to cause pressure upward against the diaphragm, to limit the excursion of the latter and so to interfere with breathing, it may be positively harmful; for the prolongation of digestion, the mechanical embarrassment of heart and the interference with breathing all throw strain

upon the circulatory system. If such strain be repeated day after day, it is inevitable that, sooner or later, permanent harm will be done to the heart and the blood vessels.

Big meals are apt, too, to be rich meals, inclusive of a heavy meat course and of many condiments. Now it happens that foods that are highly seasoned with salt, pepper and mustard not only tempt to overindulgence at the table but are in themselves stimulating to the circulation and conducive to a rise in blood pressure. The so-called "extractives" of meat—the substances in meat that are soluble in boiling water and that form the basis of meat broths—are also stimulating. So is coffee, which usually tops off the large meal; and so is the nicotine of the after-dinner cigar. Habitually heavy meals, whether they be served at noon or in the evening, are among the more important of the factors that are concerned in the origin of the arterial hypertension of later life. Particularly obnoxious is the eating of two or three heavy meals per day by persons whose habits are sedentary, and whose lives are led indoors. To such persons a period of living according to the advice of the

grim English physician who urged his patient "to live upon sixpence a day and to earn it" might be salutary!

The majority of Americans eat too much meat by far; there are but relatively few who are of normal weight or heavier who would not be better off physically if they reduced their meat-intake to a half or even to a third of the amount they have been accustomed to eat. Each person should make sure, too, that his diet is well-balanced; the ration should contain the proper proportions of proteins (meat, chicken, fish or eggs), carbohydrates (cereals, sweets), fats (butter, bacon), vitamines (fresh fruits, leafy green vegetables, milk), water and mineral salts. Each person should ascertain from one of the standard tables what the average weight is for one of his height. If his weight be much above this, or much below this, he should, under the guidance of his family physician, so modify his diet and his habits that his weight will approach the normal.

Business men, under pressure, are all too likely to eat their meals hurriedly—another bad habit. Food that is imperfectly chewed and insalivated

makes excessive demands upon the organs of digestion. If, in addition, no rest be taken after meals, the example set by every member of the animal kingdom below man being ignored, and the eater hurry back to the concentration and the worries of his work, two demands will be made upon the circulatory system where there should be but one; for the heart will be asked to pump extra blood to the vast digestive division of the circulatory system and at the same time to furnish the brain and the muscles with the amount of blood that their activities require. Certainly, in time, the heart and the blood vessels will begin to show the effects of such exorbitant demands.

Regular exercise, taken in fresh air, is essential to health and is one of the most important of the measures for the prevention of the processes that lead to high blood pressure.

An interesting commentary upon the modern man's tendencies with regard to physical exercise is furnished in the prevalence of "physical culture magazines" and "systems of home exercise." The lucrative traffic in these commodities is evidence of the difficulties that most people experience in

taking proper exercise of their own volition without the artificial incentive of some much-lauded special technique. The flabby muscles and the steadily enlarging waist-line of the average business man prove him to be niggardly in his daily allowance of pleasant muscular exercise. Street cars and automobiles are so transforming customs that the present is sometimes spoken of as the "walkless age." "Girth control" competes with "birth control" in gaining the attention of an overbusy public. Occasional sprees of intensive athletics between periods of muscular inactivity will not serve; they may be actually harmful after 40, for they throw too much sudden strain on the heart in middle age. Physical exercise should be taken in moderation, but with great regularity. Morning calisthenics practiced for 15 or 20 minutes may be enough, if they contract and stretch all of the muscles, particularly the large muscles of the trunk, and are faithfully and regularly performed, though, in addition, two or three times a week a brisk walk or a ride on horseback, a round of golf, or a string or two at the bowling alley will be advantageous. Games that actively exercise the

body are far more interesting than monotonous gymnastics; they refresh the tired mind while at the same time they compel vigorous contractions of the muscles. Exercise that is interesting is far more likely to be regularly taken than exercise that is boresome. Nor should one overdo exercise; it should never be taken to the point of great exhaustion, nor, after middle life, so violently as to cause marked breathlessness.

Sleep ought to be sound and refreshing, but there are but few adults that "sleep as sound as careless infancy." The bed should not be too soft, nor the covering too heavy or too warm. It is surprising how many people are ignorant of the comfort derivable from good mattresses and box springs. The night dress or pajamas should be of light weight, and should be worn without undergarments. Cultured persons would be astonished if they knew, as physicians do, that there are great numbers of people who do not, on going to bed, remove the underclothing that has been worn during the day! Twin beds are better for sleep than a double bed. An abundance of fresh air at night is essential. The old superstition that night air is in itself

miasmic and deadly has long ago been exploded; it was the mosquito bite, not the night air, that caused malaria. If one is frail, it is not wise, of course, to sleep in a draught, nor where the window opens directly upon the sleeper; but even in small rooms a screen will protect one sufficiently from the draught of a wide open window. More and more people are sleeping upon open porches, in winter as well as in summer, to their great advantage; the modern house that is not well-supplied with sleeping porches is incomplete. Most important of all, the cares and anxieties of the day should be shed by the mind at bedtime just as thoroughly as the clothing is removed from the body. It should not be forgotten that the business of going to sleep is just as important a part of the twenty-four hours' duty as is that of eating, or of working, or of playing. Too many persons like to continue their "vain bibble babble" far into the night and go to bed only when there seems to be nothing else to do. And some appear to regret that it is necessary to go to bed at all; they have heard that sleep "knits the raveled sleave of care," but they seem to be oblivious of the fact that their

'sleaves" have been at all frayed. Of the amount of sleep that is necessary for each person it is not possible to speak by the book. People undoubtedly vary in sleep requirements. Seven hours is probably the minimum for most grown persons; eight hours is, for many, a better allowance. And "early to bed and early to rise" is a time-worn motto that has not yet lost its value.

The elimination of harmful substances from the body demands constant attention and is largely dependent upon the formation and maintenance of several important habits. Waste products are removed from the system through the stools, the urine, the sweat, and the breath; and though the processes of removal are almost automatic, still we must see to it that the machinery is kept in good working order and that the channels of exit are not allowed to become clogged. Consider, for instance, elimination through the stools. The bowels should move satisfactorily at least once every day, and, best, at the same time each day. If they do not so move, some of the waste products are likely to be absorbed into the blood, where they may circulate and poison the tissues, before finding

their way out of the system by some other eliminative route. If the kidneys be damaged in any way, they, in turn, may fail to accomplish their whole function as scavengers. The skin, too, is an important organ for the removal of waste products, but it must be kept clean and active by bathing and friction if it is to serve adequately as a thoroughfare for the poisons that are given off through the sweat glands. Each of the trio of eliminators performs its functions best under special conditions that are provided by wholesome habits; thus the habit of eating liberally of green vegetables and fruit, and the habit of going regularly to stool will go far toward insuring a daily *satisfactory* bowel movement and the elimination of waste products through the alimentary tract; the habit of drinking plenty of water through the day favors elimination through the kidneys, and the habit of a daily bath followed by brisk friction keeps active the function of elimination through the skin. Let us then consider these habits somewhat more in detail.

The habit of going to stool at precisely the same hour each morning is perhaps the best of all ways of

avoiding constipation. The same five minutes each day should be looked forward to with the full expectation that at that exact time the bowels will be ready to function. The large intestine is an organ that is particularly amenable to strict habit in this regard; indeed, it is apt to be recalcitrant if its owner is chronologically irregular. Regular daily exercise, especially exercise that involves contractions of the muscles of the abdominal wall, is promotive of good evacuations by the bowel. Kneading the abdomen for a few minutes before rising in the morning is practiced with benefit by many people. Copious water drinking on rising, and during the day, between rather than with the meals, is also a great help to regularity of bowel movements. "Roughage" must be included in the food if satisfactory movements of the bowels are desired; for this reason the daily ration should include two or more vegetables like spinach, cabbage, asparagus, lettuce, onions, tomatoes and celery. Oatmeal contains more roughage than other cereals and brown bread and whole wheat bread contain more than bread made of bolted flour. Artificial roughage may, sometimes with advantage, be intro-

duced in the form of bran or of agar-agar. Fruits, with the exception of bananas, which are constipating to some persons, should be eaten freely. An orange or a baked apple at breakfast time, stewed prunes or stewed figs as a dessert at midday or in the evening, and a raw apple at bedtime are especially helpful.

The habit of self-drugging for constipation is pernicious. When, after a fair trial, there is difficulty in securing regular bowel movements by means of the several habits above described, a physician should be consulted, for the treatment then required may be very different in different persons. The person who attempts, in such circumstances, to treat himself may easily do himself harm.

The elimination of waste products through the kidneys is, as we have said, favored by drinking plenty of water. Six or eight glasses of water per day will not hurt the kidneys, but the drinking of too little water will result in the passage of a too-concentrated urine, which may irritate the kidneys or the bladder. The faithful kidneys can be spared much overwork and injury if we take care

to maintain the other channels of elimination (bowels; skin) in good function and thus keep down to a minimum the amounts of waste materials that circulate in the blood. There can be no doubt that the retention in the body of poisonous waste substances contributes to the development of disease of the arteries and of the kidneys. Neither the walls of the arteries nor the delicate secreting elements of the kidneys can be exposed to poisons year after year without suffering some damage; and we have seen in a former chapter that damage to either may be accompanied, as though by an echo, by high blood pressure.

The third member of the eliminative trio, the skin, is favored in its excretory function, as we have already said, by baths and by the abundant blood-supply that follows friction after a bath, or that is induced by active bodily exercise. Healthy persons should take a daily bath and rub the skin thoroughly afterwards with a rough towel. Some prefer hot baths, some lukewarm, and some vigorous young persons do not quail before the icy spigot. Warm baths are more cleansing than cold; and very cold baths are probably too severe in their

effects for any but the young. Those who take a cold plunge or shower each morning should take in addition a warm bath at bedtime or before the evening meal two or three times a week. Many like to take a warm shower in the morning, followed by a short cold shower. Though most people can accustom themselves to cold baths, there are some who do not react well to them and they should avoid them, or work up to them very gradually under expert direction. No matter what form of bath is taken, the skin should afterwards be dried thoroughly and be rubbed with a rough towel until the skin tingles and is reddened. Many, after drying the skin, go through a set of calisthenic exercises that includes rubbing of the skin with the palms of the hands.

One class of poisons that gain entrance to the circulating blood still remains to be spoken of. These are the toxins that result from growth of bacteria in some region of the body, enter the blood stream and make their effects felt at a distance from their source. It is now a well-known fact that colonies of harmful bacteria may exist for a long time in out-of-the-way places in the body, say

deep in the crypts of the tonsils, or at the roots of the teeth, or in the sinuses about the nose, or in the gall bladder. Sometimes a chronically inflamed appendix harbors them; or the prostate gland, which lies at the neck of the bladder in men, or certain of the organs of generation in women may contain such bacterial foci. Although the little plants that we call bacteria may not occasion, at least for a long time, any violent trouble at the particular spot where they grow, the poisonous substances that they give off during their growth are absorbed by the lymph and blood flowing through the infected organ and are carried to all parts of the body. Sometimes a few of the bacteria themselves get over into the blood and are carried to other parts of the body where they are killed and act as poisonous substances, or live to set up new foci of infection. Until the poisons are destroyed, neutralized or eliminated they are the cause of continuing injury to many of the body tissues; the kidneys and the joints seem to be especially prone to injury by them. These poisons are more or less steadily produced as long as the focus of bacterial infection exists. If the existence

of the focus be not suspected, through any local symptoms produced by it, as is often the case, the bacteria in it may continue their clandestine production of toxins for months or years. The oft-repeated entrance of the poisons into the blood is followed gradually by changes in the blood vessels and the kidneys. We must be sure, then, that no such "focus of infection" is allowed to exist unrecognized in any part of the body, if we would protect ourselves from injuries that may lead to various disturbances, among them the processes that lead to heightened blood pressure.

Fortunately, modern medicine has become familiar with the dangers of these little foci of infection and has developed plans by which they can be systematically sought for, discovered and removed. The freedom of our bodies from these insidious nests of dangerous bacteria is a condition worth striving for. In order to make sure of it and at the same time to find out whether the bodily functions in general, inclusive of the blood pressure, are such as to indicate health and to promise security, each person should form the habit of subjecting himself to a periodical physical examina-

tion by a competent physician. There is no other measure more likely to be of aid to us in our efforts to live out our threescore years and ten in comfort. Even in youth it is desirable that occasionally a bodily survey should be made by an experienced physician; but when the age of forty has been passed, it is folly not to take the bodily machine to the doctor for an overhauling at more or less regular intervals. The expenditure of time and money involved in submitting one's self once a year to a thorough study at the hands of some good practitioner of medicine need not be burdensome to anyone; in any case, health is so valuable that it is worth spending some time and money in order to preserve it. Fortunately, the gospel of prevention of disease is finding ever more adherents; there are now large numbers of persons who betake themselves at regular intervals, sick or well, to a doctor and ask him to ascertain their condition and to advise them so that they may be sure that they are doing nothing that is harmful or leaving anything undone that should be done for the preservation of health. It is only in this way that many of the slow, degenerative diseases

that so often develop during the years on the far side of forty can be guarded against or discovered in their incipiency and arrested. It is only in this way that the group of disorders of which high blood pressure is a symptom can be detected at a time when the physician can be of real service in preventing advance and in restoring to normal, functions that have only begun to be disturbed.

The term "curative measures" is perhaps a misnomer in connection with high blood pressure, for there is, strictly speaking, no "cure" for chronic arterial hypertension. Indeed, hypertension, as we have said, is a symptom rather than a disease. It is a symptom that appears after certain changes in the structure and in the functions of the body have occurred, some of which we have been able to trace though others still remain unknown. The high blood pressure is needed for the welfare of the body as changed; obviously, then, unless we can remove the changes that have made the higher pressure necessary, we might do harm by directly lowering the blood pressure by drugs. When the blood pressure is beginning to climb we do well to enforce the general hygienic measures that have

been described above as applicable to healthy persons who desire to keep well.

If the blood pressure has only just begun to rise and the physician's study reveals faults of hygiene, or focal infection, the correction of the hygienic faults or the removal of the infectious focus may be followed by a return of the blood pressure to normal; in such a case, the physician may have some right to assert that he has "cured" the disease-process of which the rising blood pressure was a symptom. If the high blood pressure has been long continued, and the processes that underlie it have become fixed and irreparable, there can be only amelioration; for the hypertension, it must be reiterated, is only an adaptation of the mechanics of the circulatory system to certain underlying changes. It is these changes, whatever they may be, that must be sought out and where possible removed. In their early stages, they may be removable; later on, they become fixed and irremovable. At no stage is it the part of wisdom to treat results only and to let causal conditions stand.

We have emphasized the fact that the use of drugs to reduce high blood pressure directly, ex-

cept in certain emergencies, is not rational and is rapidly falling into disuse and disrepute. Improvement of the patient's habits or changing them to suit his altered needs are the main resources of the physician in the management of patients who are found to have a high blood pressure. The patient is taught how to divorce worry, hurry and excesses of all sorts from his routine. It is desirable that his life should be calm and quiet; that he be freed from too many business and social cares, especially from those that tax his emotional nature. Relaxation should supplant tension. His sleep should be restful and plentiful; the food he eats should be moderate in amount and simple in character and he should limit rigidly his intake of meat; meat extractives and condiments should be eschewed. He should favor elimination through intestine, kidneys and skin by the methods already described. He should see to it that focal infections, in teeth, tonsils, sinuses, or elsewhere are hunted down and eradicated. He may have to pay some special attention to occupation, to climate, and to altitude; and it may be that certain patients will

at times require special mechanical or electrical treatments or a sojourn at some spa.

It is no part of the function of a small treatise intended for the general public to discuss the treatment of those later stages of patients with high blood pressure in which complications on the part of the heart, the kidneys, or the brain have begun to cause symptoms. Nothing would be gained by it. By the time such symptoms have arrived, even the most obtuse patient is likely to have realized the necessity of relying wholly upon his physician for direction.

The writers of this volume will have failed in what they set out to do, if he who has read thus far has not learned that both in the prevention and treatment of the conditions that are associated with increased blood pressure, the only safe course to pursue is to feel a strong responsibility for the observance of good personal hygiene and to turn at regular intervals to the family doctor for supervision and advice. No universal method of prevention of the hypertensive diseases can be successfully applied, nor is any single remedy a panacea after the maladies have developed. This

small volume is intended to point out where health lies and to describe the paths that lead to it; to hearten the health-seeking traveler on his way; to warn him against the seeming short-cuts into which quackery would lure him; and to assure him that, though few reach the goal of perfect health, many can live very comfortably within sight of it, if they are willing to observe a few simple but exceedingly important hygienic rules.

GLOSSARY

Abstemiousness, avoidance of excess.

Accelerator nerves of the heart, nerves whose impulses quicken the heart beat.

Anæmia, any one of several diseases of the blood.

Anæsthesia, unconsciousness produced by ether, chloroform, etc.

Analogue, that which corresponds with some other thing.

Analogy, resemblance.

Aneroid, without liquid; used of barometers and other gauges in which liquid (mercury, etc.) is replaced by some arrangement of springs.

Animate, living.

Aorta, the largest artery; it receives blood directly from the left ventricle of the heart.

Apoplexy, a condition due to injury to a blood vessel within the brain. The vessel may rupture or may be clogged by a clot. There may be sudden or gradual unconsciousness, with paralysis.

Arterial tree, the aorta and its branches.

Arteries, blood vessels which conduct the blood from the heart.

Arteriolar, pertaining to the arterioles.

Arterioles, the smallest arteries. They connect the arteries and the capillaries.

Atonic, lacking "tone"; see "tone."

Atrophy, a wasting away.

Auricle, the upper chamber in either side of the heart.

Autonomic nervous system, the special system of nerves which have to do with the control of involuntary function.

Baleful, harmful.

Barometric pressure, the pressure of the atmosphere as measured by the barometer.

Bile, the secretion of the liver.

Brachial artery, the large artery in the upper half of the arm.

Bright's disease, a common form of kidney trouble.

Caliber, diameter of the bore of a tube; for instance, of an artery.

Capillaries, the smallest blood vessels; they transmit blood from arterioles to venules.

Cardiac, pertaining to the heart.

Cerebration, action of the brain, as in thinking.

Cerebrospinal, pertaining to the brain and spinal cord.

Circulatory system, heart and blood vessels considered as a whole.

Clinical, literally, pertaining to a bed; hence, in medicine, pertaining to the study of health and disease in the patient himself.

Coitus, sexual congress.

Concomitant, accompanying.

Confluence, junction.

Conserved, maintained.

Contractile, tending or able to contract; opposite of expansile.

Coördination, harmonious adjustment.

Corollary, something that naturally follows.

Corpuscles of the blood, blood cells.

Cutaneous, pertaining to the skin.

Degeneration, state or process of impairment; deterioration.

De motu cordis, "concerning the action of the heart."

Deplete, to empty; to deprive of completely.

Diastole, the period of time during which the heart muscle is relaxed and at rest.

Diaphragm, the muscular partition between chest and abdomen; the muscle

chiefly concerned with the act of breathing.

Disparity, unlikeness.

Divergence, a turning aside; a deviation; a varying from the normal.

Dogmatically, stating an opinion, without proof, as if it were a fact.

Dysfunction, imperfect function.

Egress, act of going out, of leaving, of passage out of.

Elaborated, produced; manufactured.

Exhale, to breathe out.

Expansile, tending or able to expand; opposite of contractile.

Familial, occurring in families; used, in medicine, of characteristics and diseases which may appear in several members of a family and in more than one generation.

Fatigue, weariness from exertion.

Functional, concerned with function; not involving a change in structure. Opposed to organic.

Gastric, pertaining to the stomach.

Gastro-intestinal canal, the stomach and the intestines, considered as a whole.

Hemorrhage, bleeding; the word is not limited to bleeding from the lungs, nor does it mean the escape of a large amount of blood. Any degree of bleeding, from one drop up, in any part of the body, is a hemorrhage.

Hydrostatic, pertaining to the laws of the behavior of fluids under various conditions.

Hygiene, the science of the preservation of health.

Hyperpiesis, continued high blood pressure without demonstrable cause.

Hypertension, maximum (systolic) blood pressure persistently above the average; also the state in which such a condition persists.

Hypertonus, minimum (diastolic) blood pressure persistently above the average; also the state in which the condition persists.

Hypotension, maximum (systolic) blood pressure persistently below the average; also the state in which such a condition persists.

Hypothetical, existing only in theory; not proved.

Hypotonus, minimum (diastolic) blood pressure persistently below the average; also the state in which such a condition persists.

Impoverished, made poor; deprived of.

Inanimate, not living.

Induced, brought about; caused.

Inhibitory, tending to stop or check.

Inimical, unfavorable; adverse.

Innocuous, harmless.

Inordinate, excessive.

Insalivated, saturated with saliva.

Insidious, treacherous; appearing not so bad as it really is (when applied to a disease).

Inspiration, act of drawing in the breath.

Intermittent, occurring at intervals; not continuous.

Internal secretion, any product of gland action which is delivered by the gland directly to the circulating blood stream. The thyroid gland, for instance, is a gland of internal secretion.

Intoxication, poisoning.

Kinetic, concerned with motion.

Lacteals, the channels through which flow food materials absorbed from the intestines; they empty into the large veins.

Latent, hidden.

Ligament, a band or strand of tough fibrous tissue which holds bones together at joints or which sustains organs in place.

Lumen, the cavity of a blood vessel.

Malady, illness, disease.

Maximum, maximal, greatest, highest.

Mediate, to effect; to bring about.

Metabolic, pertaining to all the processes, taken as a whole, by which the body assimilates food, builds up its tissues, utilizes them to produce energy and maintain life, and excretes waste materials.

Miasmic, malarial.

Millimeter, one-thousandth part of a meter (a meter equals 39.37 inches).

Minimum, minimal, least, lowest.

Mm., millimeters.

Morbid, pertaining to disease.

Motor nerves, those nerves which carry impulses from the brain to the muscles.

Musculature, the muscles of the body or of any part of it.

Noxious, poisonous, harmful.

Obesity, fatness.

Occluded, stopped up, plugged.

Organ, any part of the body intended to perform a special function, as the brain, heart, stomach, kidneys, etc.

Organic, pertaining to an organ of the body, and particularly to its structure. Organic disease involves changes in body structures. Opposed to functional.

Palpate, to feel with the fingers.

Pancreatic juice, the secretion of the pancreas.

Paralysis, loss of the power of motion or of sensation.

Pathological, pertaining to disease.

Pathologist, one who studies conditions produced by disease in organs of the body.

Periodic, occurring at regular intervals.

Periphery, the edge which bounds a surface; peripheral vessels; those far away from the heart.

Perturbation, agitation of mind; anxiety.

Phenomenon, any observable fact or event.

Physiological, occurring as part of the normal activities of the body.

Pliable, flexible; supple.

Post mortem, "after death."

Potential, having power; potential energy: stored-up energy.

Presclerotic, occurring in advance of sclerosis.

Preventive medicine, that branch of medicine which aims to prevent the occurrence of disease.

Psychic, pertaining to the mind.

Pulmonary, pertaining to the lungs.

Pulse, the throbbing in the arteries caused by the passage of the wave sent out by the heart at each beat.

Pulse pressure, difference (in figures) between maximum (systolic) blood pressure and minimum (diastolic) blood pressure.

Radial artery, the artery at the wrist in which the pulse is usually counted.

Reciprocal, done by each to the other.

Recumbent, lying down.

Renal, pertaining to the kidney.

Replenishment, refilling; resupplying.

Respiration, the act of breathing.

Retrograde, in a backward direction.

Rhythmical, regularly; occurring with regularity.

Rupture, to break; applied to a blood vessel the wall of which gives away, with ensuing hemorrhage.

Saliva, spittle.

Secretory (of glands), possessing the function of secretion; (of nerves) nerves leading to such glands.

Senescent, growing old.

Sensory nerves, those nerves which carry impulses from the organs to the brain.

Simultaneous, occurring at the same moment.

Skeletal muscles, the muscles attached to the skeleton.

Sphygmomanometer, an instrument for measuring the blood pressure.

Spinal column, the backbone.

Stethoscope, an instrument for listening to sounds made by heart and lungs.

Stimulus, that which excites action. Thus light is a stimulus to the eye; motor nerve impulses are stimuli to the muscles to which they travel.

Streptococcus, a common bacterium, or "germ."

Suprarenal capsules, small glands of internal secretion situated above the kidneys.

Sympathetic nervous system, a part of the autonomic nervous system.

Symptom, an evidence of disease.

Syndrome, a group of symptoms occurring together.

Systole, the period of time during which the heart muscle is in contraction.

Tendon, a band or strand of tough fibrous tissue hrough which muscles are attached to bones.

Tensing, making tense.

Theoretical, pertaining to theory; conjectural; not proved.

Thrombosis, clotting of blood within a vessel.

Tissue, any collection of cells in the body into a definite structure. Thus there is bone tissue, nerve tissue, connective tissue, etc., each characterized by a special sort of cell.

Tone, the state of slight contraction in which all healthy muscle, both voluntary and involuntary, is kept by means of continuous slight stimuli brought to it by the nerves.

Tortuous, crooked.

Toxin, poison.

Vascular, pertaining to the blood vessels.

Vasoconstrictor, tending to cause a constriction of the blood vessels, principally of the small arteries and arterioles.

Vasodilator, tending to cause a dilatation of the blood vessels, principally of the small arteries and arterioles.

Vegetative nervous system, see autonomic nervous system.

Veins, the blood vessels which return the blood from the organs to the heart.

Vena cava, inferior, the large vein through which blood flows from trunk and legs to the right auricle of the heart.

Vena cava, superior, the large vein through which blood flows from head, neck and arms to the right auricle of the heart.

Venous, pertaining to the veins.

Ventricle, the lower chamber in either side of the heart.

Venules, the smallest veins; they receive blood from the capillaries and transmit it to the larger veins.

Vessels (or blood vessels), the tubes through which blood flows.

Viscosity, stickiness; the quality of being sticky, ropy, or glutinous.

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